ASSOCIATION BETWEEN INCOME AND HOSPITAL BURDEN FOR CHILDBIRTH IN CANADA

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ABSTRACT

Rationale: Analyzing national hospital utilization administrative data in the context of individual-level socioeconomic disparities poses an opportunity to examine variation in hospital burden among different subpopulations. Birth and delivery in hospital is one of the most common medical procedures in Canadian hospitals and can be used to assess equity in the delivery of health care.

Objective: This study investigates the association between socioeconomic status (measured principally by household income but also maternal education level and Aboriginal status) and hospital burden for childbirth using linked Canadian survey and administrative databases, accounting for a wide array of other individual and health-care related characteristics.

Methods: A population-based record linkage between national health survey data and the Canadian Discharge Abstract Database (a record of all Canadian hospital separations) allowed the tracking of hospital utilization between 2005 and 2009 for which individual-level socioeconomic and demographic factors were also available. Length of stay for delivery, risk of pre-delivery hospitalization within 30 days of admission for delivery, and risk of maternal readmission within 30 days of discharge for delivery were the three measures of hospital utilization modeled.

Results: 7,628 birth-related discharge abstracts attributed to 5,931 women were extracted. Complete information for 7,163 deliveries of 5,568 women was available and used in the models of length of stay and risk of maternal admission pre- and post-delivery. In fully adjusted models, predicted length of stay was modestly graded by household income with longest stays for lowest income women (2.79 days, 95% CI 2.61-2.92), followed by middle income women (2.63 days,

95% CI 2.50-2.76) and, in turn, high income women (2.56 days, 95% CI 2.49-2.63). Factors intrinsic to routine hospital care and protocol such as province and vaginal versus Caesarian section delivery were stronger predictors of length of stay than income. Average predicted length of stay also declined from 2.79 to 2.38 days over the study period. Additionally, Aboriginal status, compounded with residing in a rural setting was imprecisely associated with higher predicted probability of maternal readmission (3.66%, 95% CI 0.50-6.83) as compared to Aboriginal women living in urban areas (1.37%, 95% CI 0.24-2.50) and Non-Aboriginal women in both urban (1.28%, 95% CI 0.95-1.60) and rural areas (1.11%, 95% CI 0.57-1.65).

Conclusions: Hospital burden for childbirth in Canada is primarily driven by biological and regional differences, rather than by socioeconomic position. However, low-income women appear to have marginally longer stays in hospital following birth events than do middle and high-income women in Canada, and this pattern persists after adjustment for strong drivers of length of stay (parity and birth mode). While this may suggest that more complicated cases are benefiting from longer stays in hospital, it provokes the question as to whether there may be additional reductions in length of stay that could be achieved through resource redistribution to the prenatal period.

ABRÉGÉ

Justification: L'analyse de données administratives d'utilisation d'hôpital dans le contexte de disparités socio-économiques au niveau individuel offre une opportunité d'examiner la variation du fardeau hospitalier parmi des sous-populations différentes. La naissance et l'accouchement en milieu hospitalier sont des procédures médicales des plus communes dans les hôpitaux canadiens et peuvent être utilisées pour évaluer l'équité dans la prestation des soins de santé.

Objectif: Cette étude examine l'association entre le statut socioéconomique (mesuré principalement par le revenu du ménage, mais aussi par le niveau d'éducation de la mère et le statut d'autochtone) et le fardeau hospitalier pour les naissances en utilisant une liaison entre l'enquête sur la santé dans les collectivités canadiennes et des bases de données administratives, prenant en compte un large éventail de caractéristiques individuelles ainsi que d'autres reliées à l'état de santé.

Méthodes: Un couplage des dossiers de la population entre les données de l'enquête nationale sur la santé et la Base de Données sur le Congé des Patients (un registre de tous les congés des hôpitaux canadiens) nous a permis de suivre l'utilisation de l'hôpital au niveau individuel lorsque les facteurs socioéconomiques et démographiques étaient également disponibles à ce niveau. Les données couplées couvrent les congés d'hôpital entre 2005 et 2009. Durée de séjour pour accouchement, risque d'hospitalisation avant l'accouchement dans les 30 jours précédant l'admission pour accouchement et risque de réadmission de la mère dans les 30 jours suivant le congé pour l'accouchement étaient les trois mesures d'utilisation d'hôpital modélisées.

Résultats: 7,628 résumés de congés reliés aux naissances attribués à 5,931 femmes ont été extraits. L'information complète pour 7,163 accouchements de 5,568 femmes était disponible et

a été utilisée dans des modèles de durée de séjour et de risque d'admission de la mère avant et après l'accouchement. Dans les modèles complètement ajustés, la durée de séjour prédite était modérée par le revenu du ménage, les durées de séjour les plus longues étant associées aux femmes avec le revenu le plus bas (2.79 jours, 95% IC 2.61-2.92), suivies par les femmes au revenu moyen (2.63 jours, 95% IC 2.50-2.76) et ensuite les femmes au revenu élevé (2.56 jours, 95% IC 2.49-2.63). Des facteurs intrinsèques aux soins hospitaliers de routine et protocole tels que province et accouchement par voie vaginale versus par césarienne étaient des prédicteurs plus puissants pour la durée du séjour que le revenu. La durée moyenne c'est déclinée de 2.79 a 2.38 pendant la période d'étude. De plus, le statut d'autochtone, combiné avec résider dans un milieu rural, était associé avec une probabilité prédite plus élevée de réadmission de la mère (3.66%, 95% IC 0.50-6.83) comparé aux femmes autochtones vivant en milieu urbain (1.37%, 95% IC 0.24-2.50) et aux femmes non-autochtones vivant en milieux urbain (1.28%, 95% IC 0.95-1.60) et rural (1.11% 95% IC 0.57-1.65).

Conclusions: Le fardeau d'accouchement aux hopiteaux Canadiennes est d'abord lié aux différences biologiques et régionales au lieu d'une position socioéconomique. Les femmes à faible revenu ont des séjours en hôpital marginalement plus longs suivant les évènements de naissance que les femmes au revenu moyen ou élevé au Canada et ceci persiste suite à l'ajustement pour des puissants moteurs de la durée du séjour (mode de naissance et parité). Même si ceci peut suggérer que les cas plus compliqués bénéficient de plus longs séjours à l'hôpital, cela provoque la question de savoir si des réductions supplémentaires de la durée du séjour pourraient être atteintes grâce à la redistribution des ressources à la période prénatale.

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ABBREVIATIONS

AB	Alberta
BC	British Columbia
C-section	Caesarian section
CCHS	Canadian Community Health Survey
CIHI	Canadian Institute for Health Information
CMG	Case Mix Group
CPSS	Canadian Perinatal Surveillance System
DAD	Discharge Abstract Database
ED	Emergency Department
HIN	Health Insurance Number
IRR	Incidence Rate Ratio
LBW	Low Birth Weight
LOS	Length of stay
MB	Manitoba
NB	New Brunswick
NICU	Neonatal Intensive Care Unit
NL	Newfoundland and Labrador
NS	Nova Scotia
NT	Northwest Territories
NU	Nunavut
ON	Ontario
PE	Prince Edward Island
PNC	Prenatal care
PTB	Pre-term Birth
SES	Socioeconomic status
SGA	Small for Gestational Age
SK	Saskatchewan
SOGC	Society of Obstetricians and Gynaecologists Canada
YT	Yukon Territory

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CHAPTER 1: INTRODUCTION

Canada is facing the problem of rising hospital expenditures as one of the top ten health care spenders in the world (1). Recent austerity measures at both provincial and national levels have motivated a call for reducing costs in the public sector. These cuts will have disproportionately larger consequences for socioeconomically disadvantaged individuals who use the system more (2, 3). Even in a setting with universal access to public health insurance, Canadian studies reveal disparities in disease prevalence and cumulative health care costs among low-income patients as compared with higher-income patients (4-6). Patients of lower socioeconomic status (SES) are also more likely to access health care services through costly and inefficient means such as the emergency departments (7-9) and suffer more illness and poorer health outcomes (10), despite higher hospital utilization (11, 12). Numerous bodies of research support the link between poor health, low-income and income inequality (13). Comparatively fewer have considered what the excess burden of socioeconomic disparities might be.

Childbirth constitutes a large proportion of overall hospital activity, and in turn - expenditure. Low-income women are less adequately resourced to cope with crucial health events such as childbirth, and often have less access to preventive health measures such as prenatal care (14). Infants from socioeconomically deprived families exhibit disproportionately higher adverse birth outcomes as well as utilization differences. Canadian research and surveillance efforts (15-18) have focused on monitoring population-wide pregnancy outcomes in an effort to shape health care policy. However, national data often contain limited individual-level maternal factors. While multiple Canadian studies have investigated the relationship between SES and disparities

in adverse pregnancy outcomes [15-19], few have evaluated health care utilization attached to those outcomes (19-21).

The purpose of this study is to determine whether hospital burden for childbirth is patterned according to women's income, as well as to other socio-demographic characteristics. The overarching hypothesis of this thesis is that low income is a risk factor for excess hospital burden related to childbirth in Canada. The specific objectives of the thesis are: 1) to estimate the determinants of length of stay and maternal admissions for birth in Canada with an emphasis on income as a modifiable determinant, and 2) to better understand the status of maternal health and socio-demographic factors in the context of a publicly funded health care system.

This is a traditionally formatted thesis. Chapter Two provides a review of three key bodies of literature: 1) hospital utilization for childbirth, 2) socioeconomic patterning of child and maternal health, and 3) the use of record linkage to study SES and population health. Chapter Three summarizes the population-based approach taken to assess the association between income and hospital utilization, using a multi-province/territory record linkage, and Chapter Four presents the results of the analysis. Chapter Five discusses the results in the context of Canadian trends in childbirth and maternal socioeconomic status. Lastly, Chapter Six offers an appraisal of the substantive, methodological, and policy contributions of this research, as well as the strengths and limitations of the study.

CHAPTER 2: LITERATURE REVIEW

In order to address how individual-level maternal socioeconomic determinants is linked to hospitalization for birth, this chapter reviews three key bodies of literature: 1) hospital utilization for childbirth, 2) socioeconomic patterning of child and maternal health, and 3) the use of record linkage to study SES and population health. First, I provide a brief overview of the state of hospital utilization for childbirth in Canada, what services are offered with regard to medical care for delivery, and how these services may differ regionally. Next, I review what is known of the socioeconomic patterning of child and maternal health. I describe the gendered relationship between socioeconomic status and health, and then explain what is known about SES and childbirth, with particular focus on income-related measures. Lastly, I explain what record linkage is, what it entails, and discuss its use for studying individual-level socioeconomic factors and health outcomes. The information contained in this section also presents a conceptual framework for the analysis of income and health care utilization using population-wide data.

2.1 Hospital utilization for birth and delivery in Canada

Childbirth is currently the most common reason for hospitalization across Canada. Deliveries represent a large percentage of hospital activity; there are an estimated 385,000 annual births in Canada (22) and these account for approximately 6% of total inpatient costs (23). While out-of-hospital births are a rising trend, only 1% of deliveries occur outside of the hospital (i.e. home, birthing centres) (23). The vast majority of births takes place in acute care hospitals and is recorded in hospital administrative databases – a favourable reality for investigators looking to analyze this data at a population level.

Delivery by Caesarian section (C-section) is the most common kind of inpatient surgical procedure at over 100,000 surgeries in 2012-2013, which isnearly double that of knee replacement, the second most common surgery (15). Hospital deliveries also act as a good litmus test of functioning health care system because they are so routine and standardized (24). Overall, childbirth remains an important health event at a crucial time for child health and development, and also represents a key aspect of women's reproductive health.

Rates of growth in all health care expenditures have slowed in recent years, and increases in spending are projected to continue at 2.1% annually, reaching 11% of the country's GDP (25). There is considerable interest in monitoring hospital utilization patterns for budgetary planning and cost containment by governments, in addition to assessing potential inefficiencies in health care delivery. In settings where socioeconomic and demographic data are collected alongside utilization statistics, utilization data can also help determine whether access and delivery is equitable and effective between sub-populations.

CANADIAN HEALTH CARE SYSTEM

There are many factors that affect the volume and nature of hospital utilization, but there are two overarching explanations for why hospital use might be higher or lower. On the one hand, lower hospital burden might indicate the population is composed of healthy individuals that do not need to visit the hospital. On the other hand, it could mean barriers exist that impede access to hospitalization. Similarly, higher hospital use might mean individuals are sicker and need more health care, but it could also mean certain individuals just have better access. In Canada, it is assumed that under a system of universal public health care, everyone has equal access to services. This characteristic makes it a useful place to study health care utilization, because one

might be able to make the assumption that differences in health care utilization have much less to do with access, and much more to do with health status.

Canada has a long history of leadership in health care practice and access, shaped by key pieces of legislation such as the Canadian Health Act of 1984. The Act outlines five principles for national health care provision: public administration, comprehensiveness, universality, portability, and accessibility. Particularly relevant to this study, "comprehensiveness" refers to the commitment of the health care system to provide and insure all necessary medical services, while "universality" means all insured individuals are entitled to the same level of health care – regardless of one's ability to pay (26). The Canadian health care system delivers and finances care through a combination of public and private entities. The federal and provincial/territorial governments provide public funding and determine health policy and care standards, while private entities are responsible for delivery. Although national standards of health care are in place, individual provinces and territories are allotted funding from the federal government and have considerable jurisdiction over health care access and delivery. Canada then, in reality, has multiple health care systems with hospital and physician care delivered by the various provincial and territorial governments.

CURRENT STATE OF PERINATAL CARE IN CANADA

Delivery in hospital is a routine procedure deemed medically necessary and thus, is publicly financed across the country. Even so, provincial and territorial differences in maternal care exist, which vary further in access by urban and rural setting. The nature of these differences involves the health care providers delivering these services (family physicians, midwives, nurses), as well as practice and policy variations by regional health authority and facility. The variation in Caesarian rates and epidural rates by province and territory exemplify this point. Epidural rates

between 2013 and 2014 had ranged from 6.5% in Nunavut to 72% in Quebec (15). Provinces also differ on whether they finance and regulate other aspects of service provision for pregnancy. Whether a family physician, obstetrician or midwife attends the delivery is one of these aspects (17). Midwifery is both funded and regulated by some provinces such as Ontario and BC, but is not funded and/or regulated in others (23). The availability and choice to have a midwife likely affects the proportion of deliveries that take place in acute care facilities by province, and will also mean supportive maternal care differs leading up to delivery. The provision and providers of prenatal care (PNC) also vary by province/territory. A national population-based survey did find, however, that all women in their sample received timely PNC (27).

QUANTIFYING HOSPITAL UTILIZATION

Monitoring and measuring health care utilization in Canada poses a challenge to government and policymakers due to the provincial variation in delivery of care as well as the variety of methods and approaches health authorities might take in such a venture (28). Hospital utilization refers broadly to the manner in which a population makes use of its available hospital resources, and has most commonly been measured by length of stay (LOS) and rate of readmission. While the methodology for the measurement of utilization continues to be advanced (29), these two traditional measures of utilization volume remain commonly employed. LOS and readmission rates are also easily compared across populations and time. A summary of LOS and readmission as measures of hospital utilization, and their specific application in studies of hospital burden related to childbirth follows.

Length of Stay (LOS) describes the duration of time spent for a single hospital episode, often taken as the number of inpatient days from the day of admission to the day of discharge. The number of days spent in hospital is typically seen as an indicator for inpatient resource use and

efficiency, as well as a measure of quality of care (30). Due to its ease of use and historical collection, LOS has been consistently used as a measure of hospital burden comparable across different institutions, settings, and even countries. LOS is often adjusted for classification based on diagnosis and intervention in order to adjust for characteristic resource use of different kinds of patients, often called case mix groups.

The average LOS for delivery in Canada from 2013-2014 was 2.3 days (15). Average LOS varies by delivery characteristics (23), by province/territory (23), and by biological factors such as maternal age (31) and parity. Since 1984, Canada has made considerable efforts to shorten LOS for childbirth. The chief motivation for early discharge is to increase health care efficiency and reduce costs, which are substantial in the realm of such a routine procedure. However, some studies have questioned whether early postpartum discharge might negatively affect maternal or neonatal health (32, 33). Inadequate duration or quality of care could be evaluated in part by readmission for needs that were perhaps unmet during the previous visit.

Studies point to a connection between shorter postpartum stays and higher rates of neonatal readmissions in Canada (32-36) and elsewhere (37-39). One study estimated that an increase in postpartum stay of 12 hours was sufficient to observe a 0.6% reduction in the readmission rate (35). An Australian study found that while hospital stay for delivery decreased from 3.7 to 3.4 days between 2001 and 2007, maternal readmission rates did not increase, and had in fact fallen somewhat from 3.4% to 3.0% (40). In Canada, shorter LOS has been associated with increased risk of maternal readmission for Caesarian births (41) in particular.

Expanding utilization analyses to other measures such as rates of readmission allows us to interpret LOS within the context of other utilization metrics such as re-hospitalization rates. A single LOS measurement has limited information about patient outcomes over a particular

episode of care (42). Readmission as an outcome measure is traditionally defined as a subsequent admission to hospital within 30 days of a previous discharge. Canadian studies, however, have used a period as long as four months (43). With the distinction between neonatal readmission and maternal readmission, studying neonatal readmissions requires linking maternal and newborn hospital discharge abstracts in order to assess birth outcomes in connection with maternal characteristics and obstetric history – a difficult data requirement and one that was not available for this thesis.

Studies have consistently found delivery by C-section to be an important determinant of maternal readmission. The major reasons for readmission following a C-section birth are postpartum hemorrhage, puerperal infection, and hypertensive disorders (41, 43, 44). The Public Health Agency of Canada also found higher rates of readmission associated with C-section births using national data (16). In addition, they found 90-day maternal readmission rates ranged between 1.5-2.0 readmissions per 100 deliveries for vaginal births, and 2.7-3.7 readmissions per 100 deliveries between 1995 and 2005 (16) for C-section births. These readmission rates are comparable to a 120-day readmission rate of 4% from a Canadian national study conducted in 1998 (43).

UTILIZATION ASPECTS FOR HOSPITAL DELIVERIES

In order to understand how hospital utilization for birth and delivery might vary by SES, some clinical background on the medical procedures and interventions that underpin differences in resource use is necessary. Infant deliveries make up a significant proportion of hospital activities, and remain one of the leading reasons for hospitalization across OECD countries (45). Four birth-related diagnoses of various degrees of complexity occupy the top ten most expensive kinds of hospitalizations in Canada, with vaginal birth requiring anaesthesia and

obstetric/gynecologic intervention in fourth place at $233 million total in costs (25). With regard to intervention, primary C-sections without induction make up the 8th most expensive hospitalization type. In Canada, CIHI has attempted to capture these resource-utilization differences in developing a Case Mix Group (CMG) methodology.

There are three major determinants of resource utilization unique to hospital births: mode of delivery, medical procedures done during labour (such as labour induction or fetal heart monitoring), and medical procedures required to aid in delivery (such as use of forceps or vacuum extraction). The most influential determinant of hospital utilization for childbirth is the mode of delivery. C-sections are considered major surgery, and are often medically essential in cases such as pre-eclampsia, dystocia (non-progressive labour), fetal distress, breech presentation, active genital herpes, multiple births, large fetal size, and previous C-section birth (46). CIHI estimates the cost of an average vaginal delivery at $2,800. The cost of an average C-section is much higher at approximately $4,600 (23). Delivery by C-section often carries greater risk of infection and other complications as observed in Canada in the Maternity Experiences Survey (47) . For this and other reasons, the World Health Organization (WHO) recommends reducing primary C-section rates (defined as a C-section that is performed for the first time on a pregnant woman) to 10-15% (48). C-section rates are on the rise in Canada (46) and this suggests a corresponding increase in hospital burden worthy of future study.

Adverse birth outcomes and poorer maternal health generally require greater medical intervention, ultimately translating to higher resource use for hospitals. For instance, increased healthcare burden for outcomes such as preterm birth (49-51) and small for gestational age (SGA) (52) have been observed. In 2011, CIHI estimated that average maternal care costs for singleton births were $2,922 for non-complicated pregnancies in 2005, but increased by about

25% to $3,687 for complicated pregnancies, with similar trends for labour complications and preterm birth (31). Moreover, the severity of the adverse birth condition seems to increase hospital burden and cost, and has been found in the case of prematurity (53). Although the lower utilization seen in prenatal care and emergency department (ED) use are sensitive to maternal health-seeking behaviors (54), Canadian studies report socioeconomic variations in the use of these services which could point to economic, structural, as well as psychosocial barriers to accessing this care (14, 55). The presence of poor health outcomes at birth might also lead to increased health care costs later in childhood, and has been seen in the particular case of PTB and complications of PTB (56-58). Overall, there should be great societal interest in ensuring an excellent and equitable continuum of care, ideally from pre-conception through the prenatal and birth experiences as well as through child and young adulthood to ensure the best possible conditions for success in educational, labour market and disease outcomes in later life. Child and maternal health is population health.

2.2 Socioeconomic Patterning of Maternal and Child Health related to Childbirth

Childbirth is a key health event for both child and maternal health, and has been studied extensively in relation to clinical and maternal characteristics. This section describes what is known about socioeconomic status and child and maternal health outcomes in the Canadian context. I first describe the social position of Canadian women. I then summarize socioeconomic (SES) variables that have been linked to birth and delivery, with a focus on income as a measure of SES.

SOCIOECONOMIC DISPARITIES IN WOMEN'S HEALTH

Socioeconomic status (SES) is now widely accepted as a multidimensional, modifiable determinant of health. Traditionally assessed with respect to income, education, and/or

employment, SES aims to convey individual or group access to resources necessary to achieve and maintain good health (59). Individuals with higher SES have greater means to acquire basic necessities needed for health and well-being such as nutrition and housing, in addition to health care services and goods (60). Women make up a growing and disproportionate fraction of the poor in Canada, often referred to as the feminization of poverty (61). Barriers to accessing reproductive health care are linked to poverty (62, 63). Women of low SES are often in worse general health, and have pre-existing conditions such as obesity, diabetes, mental health and substance abuse that place them at increased risk for pregnancy complications (64).

Women as a group are also substantial consumers of health care services, with specific and changing healthcare needs throughout life that are biologically driven (65) but also socially and culturally influenced (66, 67). Canadian women have been estimated to accrue, on average, 40% higher hospitalization costs than men over their lifetime (68). The feminization of poverty is a global reality that impacts women's health (69). Systemic gender inequality frequently accompanied by disparities in social, economic, and political factors compounds the justification for women's health care. Low-SES women constitute a vulnerable population and face added challenges of reproductive and maternal health events such as childbirth. For this reason, women's health care utilization warrants special consideration.

SOCIOECONOMIC STATUS AND CHILDBIRTH

Considerable research efforts have been made in the area of childbirth and maternal health with regard to socioeconomic status, and have also been reviewed extensively in the context of birth weight, gestational age, and intrauterine growth (70-72) as well as perinatal and maternal mortality and morbidity (73), finding consistently inverse associations between income and adverse maternal and birth outcomes. In the case of maternal health and childbirth, low SES

could contribute to suboptimal maternal nutrition and in the perinatal period, fewer resources for reproductive and childhood health and development in particular (74). Inadequate material conditions to maintain overall health and well-being are part of the experience of being low-SES, and further compounds structural challenges women already face. External SES conditions have also been proposed to operate through physiological stress response pathways, negatively impacting maternal and child health (75). Prenatal health care underutilization has been linked to poverty, lack of transportation, and fewer social supports such as child care (76-80).

Women's poverty also has long-term consequences that extend beyond childbirth and maternal health. Health at any given time in the life course is a function of past experiences and there is mounting evidence to suggest that early life exposures at pregnancy and in childhood shape health later on in adulthood (81). From a developmental and life-course perspective, it is becoming increasingly accepted that early-life SES exposures shape and determine health status over a lifetime (82). Socioeconomic status is associated with rates of childhood hospitalization. One American cohort study of 105,624 children with a total of 116,636 hospitalizations found that those living in the lowest household income areas had the highest pediatric hospitalization costs for common medical conditions (83). Child cognitive and behavioral development is associated with multiple SES factors, and this relationship varies over the first few years of life (84).

INCOME-RELATED MEASURES OF SES AND CHILDBIRTH

Perhaps the most widely used and intuitive indicator of SES is income, a traditional measure of economic resources. Poverty is understood as a condition of deprivation and an element of socioeconomic disadvantage. Population-based studies and surveys frequently use household income as an indicator of SES, the combined income of all individuals in a given household. The

inclusion of the element of living in a household takes into account the sharing of resources as well as expenses. Household income is often adjusted for household size, in addition to being adjusted for other population-level aspects such as income relative to regional income. However, income variables carry weaknesses that can limit their reliability and validity as a measure of SES, which have been extensively described (59). Income also varies with age, and is economically and socially meaningful to women and childbearing. In contrast to other more enduring variables like education, current income is relatively unstable, and questions related to income on surveys of all kinds tend to elicit refusals or incorrect responses from respondents. An additional limitation of household income as a measure of SES for women is the inability of this measure to elicit the control over and distribution of household financial resources. A variety of other income-related measures have been developed to capture different aspects of SES in different datasets and settings. These include composite indices of many aggregated SES factors, or contextual and area-based measures such as neighborhood poverty (59). However, unlike composite variables that are often difficult to interpret and not widely adopted, household income as a variable remains valuable because of its widespread and continued collection as a standard survey item, as well as being directly meaningful to individual access to material resources.

Poverty implies material and social deprivation, and is likely to overlap with other life challenges such as teenage pregnancy, unemployment, lone motherhood, and poor living conditions – all of which have also been linked to poorer child and maternal health outcomes (74). Several Canadian studies have examined the relationship between income-related measures and health outcomes related to childbirth using population-based linked data from birth cohorts (85-87), provincial birth registries (88-90) or databases (89, 91) and vital statistics and census data (90,

92-94). National-level studies of SES and birth outcomes (92, 95, 96) have most commonly relied on the Canadian Maternal Experiences Survey (MES), which contains specific information on childbirth and maternal characteristics.

Area-level proxy measures of income are typically used in studies of birth outcomes (provincial linked data such as the Nova Scotia Atlee Database and the MES survey are notable exceptions (89, 91)). One study used income assistance status as an indicator (97) from the Saskatoon birth registry. One other study used both individual level and area-level Low Income Cut-Off measures (LICO) in their analysis (92). Health outcomes are focused on neonatal conditions, including pre-term birth (PTB), small for gestational age (SGA), low birth weight (LBW), perinatal death and morbidity. Fewer studies examine maternal health outcomes in detail, and are often restricted to postpartum depression (92, 95). Investigators adjust for a number of different covariates, depending on the nature of the analysis and the population. These often include maternal and pregnancy characteristics known to be associated with income and birth outcomes such as parity, maternal age, race, and marital status. Rural residence and Aboriginal status are also essential characteristics of the Canadian population that have exhibited differences in health care and outcomes; the role of the latter has never been assessed in national level analyses.

Most often, studies report an inverse relationship between poor birth outcomes and income-level. However, some studies have shown the relationship to hold for some complications and less so or inversely for other complications (87, 90, 96), or have shown little difference in the prevalence of poor outcomes by income status after adjusting for covariates (91). Rural status (88) as well as immigrant status (95) have been assessed for effect measure modification, and a systematic review of 106 articles identified race/ethnicity as an important factor in the relationship between SES and adverse birth outcomes (70). There is strong Canadian evidence

based on key studies (85-98) and reviews (70, 71) for the link between income-related SES and adverse birth outcomes. What is less clear is whether a similar relationship can be observed for socioeconomic variations in hospital burden.

OTHER FACTORS ASSOCIATED WITH CHILDBIRTH

In this section, I summarize other major socioeconomic/demographic factors (maternal education, urban and rural residence, recent immigrant status, Aboriginal status, marital status) as well as biological factors (maternal age and parity) that have been a focus of past research in relation to childbirth, and are important to account for in studying the relationship between income and health care resource use for childbirth.

Maternal education is often used as a measure of SES because of its relative stability throughout the life-course, and because it may imply capacity for knowledge of self-care through pregnancy and delivery. Maternal educational attainment is thought to affect the success of childbirth through the added social and economic resources a woman might accrue with greater social and employment opportunity. Disparities in maternal education have been associated with higher risks of adverse birth outcomes, independent of income (86, 99), and could become less of a protective factor for childbirth with age (100). There is also a reverse relationship whereby early childbearing affects maternal education, as the burden of childcare disproportionately placed on women potentially limits future educational opportunities (101). Since adolescent mothers who would not have had the chance to complete their schooling, educational attainment is not a particularly effective metric for younger mothers (102).

In Canada, population demographics, health care access, and utilization differ considerably by the **urban and rural divide** (103). “Rural” has been defined by Statistics Canada as all towns and municipalities outside commuting zones of large urban centres with populations of 10,000

people of more. Residing in rural areas has been associated with higher risk of adverse birth outcomes (103, 104) yet lower health care utilization for childbirth (105), and appears also to be modified by maternal income (88) and education (106).

Recent immigrant status is an element of Canada's uniquely diverse population of individuals. Recently immigrated women face particular barriers accessing health care for childbirth such as lack of public insurance, language barriers, and cultural differences (107-110). Immigrant women also tend to differ from non-immigrant Canadian women on various socioeconomic factors, and have reported lower income than women born in Canada (107).

Aboriginal status refers to Indigenous populations (First Nations, Inuit, and Metis) and their descendants. According to the 2011 National Household Survey, Aboriginal people make up 4.3% of the Canadian population, with almost half of the First Nations population residing on reserves as of 2011. The health disparities between Aboriginal and non-Aboriginal Canadians are egregious, however they are measured (111-113). In relation to childbirth and maternal health, the challenges for Aboriginal women are amplified by Canada's history of colonialism and systematic marginalization, which are deeply racialized and gendered. Evidence for the persistence of disparities in adverse birth outcomes for Aboriginal women relative to non-Aboriginal women has also been shown (114-116), including PTB, macrosomia, and infant death. Aboriginal women tend to receive less prenatal care (14, 117), and experience higher rates of teenage pregnancy (118).

Given the historical context of Native reserves, the gradual shift away from rural residency to urban residency, and the importance of environmental connection to Aboriginal health and community (119), some studies have pointed to the importance of exploring potential interaction between these factors. Frequent movement from rural settings to and within urban settings, often

due to lack of neighborhood safety (120) has also been found to negatively influence health and health care utilization among Aboriginal people (121).

Marital status is often understood as a source of social support and stability in childbirth (122), and its association is modified by age, race, and maternal education(123). Lone mothers face the economic challenges presented by pregnancy and childbirth, and in Canada, make up one of the poorest demographic groups (124). Unmarried status is considered a risk factor for poorer birth outcomes, and has been connected to higher rates of LBW and infant mortality (125, 126). Small gradients in adverse birth outcomes have even been observed between women in common-law relationships and those legally married, both of which had fewer complications than women without a partner (125) (note that these estimates were not adjusted for any measure of SES).

Maternal age has been found to influence pregnancy and childbirth through biological as well as socioeconomic pathways. Pregnancy in older women has increased in many countries, driven in part by social factors (127). Entry of women in the workforce, opening of educational opportunities to women, development of contraceptive and reproductive technologies and changing family social dynamics have collectively enabled women to control and delay childbearing. Delayed childbirth, however, does carry with it some biological implications, such as elevated risk of preeclampsia, gestational diabetes, intrauterine fetal death, LBW, PTB (128), and delivery by Caesarian section (129, 130).

On the other end of the spectrum, adolescent pregnancy also carries greater risk of adverse birth outcomes (131) and excess neonatal re-hospitalization (132, 133). Worldwide, 10% of deliveries are attributed to teenage pregnancies (134). According to Statistics Canada, the live birth rate of teenage girls was 4.1% in 2006 (135), and while the national rates seem to have leveled off since 2001, four provinces (New Brunswick, Newfoundland, Nova Scotia, and Manitoba) have

experienced increases in teen pregnancy by 15% or more between 2006 and 2010 (136). Higher SES could be protective and mitigate hospitalization in infants of teenaged mothers (137).

Nulliparous women have been found to experience higher rates of PTB and LBW (138), and can overlap with other risk factors for adverse birth outcomes such as young maternal age, the latter having been found to be associated with increased neonatal admission to hospital (139). The differences in adverse birth outcomes between nulliparous and multiparous women may also be linked with evidence of fewer subsequent pregnancies from women who have had adverse birth outcomes in their previous deliveries (140).

2.3 Linked Data

An important methodological feature of my study is the analysis of linked population-based data. In this section, I provide a brief rationale for records linkage, a summary of the linkage process and the data typically used. I close with a few examples of Canadian initiatives using linked data for research on birth and delivery.

RECORDS LINKAGE

Records linkage refers to the merging of data from different sources that are likely to describe the same individual, family, or other entity (141). The key advantage of record linkage is the use of information that already exists (142). For this reason, studies using linked data are often less costly than the development of an epidemiological cohort for prospective study. Data linkage studies also tend to be quite powerful, especially in situations where evaluating the status of virtually the entire population is made possible (as in the case of registries covering an entire population). In these cases, an individual's inclusion in the denominator is not dependent on hospital admission, or survey participation (143). Records linkage presents an efficient use of

resources and allows researchers to mimic longitudinal cohort-like data with routinely collected information originally intended for operational and not necessarily research purposes.

There are two main approaches to linking records after the data are cleaned and deemed suitable for the linkage process. Deterministic linkage relies on the presence of a universal unique identifier in the datasets (most often a health card number in the Canadian context), and establishes a match if the values agree. For some countries with strong health and population surveillance systems utilizing high quality key identifiers, such an approach is possible. However, the linkage is prone to false positives if the identifiers are imprecise, weak, or unstable over time. Moreover, there is no way to assess the quality of the links made, nor allow for the possibility of partial linkage (144).

Probabilistic linkage involves the use of multiple key variables to generate a probability that two records from each database belong to the same individual. The probability is calculated by generating weights for each variable included, depending on how unique and powerful the variable is in establishing a link. Scores for these weights are summed and records are considered "linked" based on a threshold value. Statistics Canada has focused specifically on developing a computerized approach to probabilistic linkage called the Generalized Records Linkage System (GRLS) (145). GRLS is one of two main probabilistic linkage software packages widely used (146). The success of linkage results using deterministic and probabilistic methods of linking Canadian census data to hospital data are comparable, and implies that probabilistic approaches yield high quality linkages in the absence of unique identifiers (147).

Administrative data on health care utilization is often highly reliable, consistently collected, and covers entire populations. It is then highly desirable as a component of a linked dataset. Population-wide hospital databases and medical claims are essential to estimating health care

costs and the burden of disease (148). As thoroughly summarized previously (149, 150), there are a number of limitations in pursuing the use of administrative data for healthcare research. These limitations include challenges to data quality, missing data and a lack of detail and contextual information (especially about health related behaviours and social determinants of health). Administrative data is ideally paired with survey data containing individual-level demographic, socioeconomic, and behavioral information. Data linkage is becoming an important tool in research on maternal and child health, both in Canada (151) and elsewhere (152).

CANADIAN EXAMPLES OF DATA ON CHILD AND MATERNAL HEALTH

The use of different data sources and records linkage for childbirth in Canada depends on whether the analysis is regional or national. Many studies that utilize administrative and linked data take place at the provincial or regional level, and often differ at this level too. For instance, studies conducted on Manitoba administrative health care utilization databases were more likely to assess hospital utilization as compared to studies done on Saskatchewan administrative health care databases, which were more likely to focus on risk factors and health outcomes (153).

There have also been a number of large-scale research efforts to examine childbirth data at a national level - both led by academic and government organizations. The most common data sources for Canada-wide childbirth studies are the Statistics Canada Vital Statistics System for its birth registry, CIHI's Discharge Abstract Database (DAD), as well as the discontinued National Longitudinal Survey of Children and Youth (NLSCY). The Maternal Infant Child and Youth Research Network (MICYRN) maintains a web-based inventory of Canadian birth cohort studies (154), and also lists seven Canadian research networks dedicated to reproductive health and childbirth. The only network listed that utilizes data from all provinces and territories is the

Canadian Perinatal Surveillance System (CPSS), a health surveillance initiative of the Public Health Agency of Canada (PHAC). The CPSS has been widely used in population-based research on maternal and child health outcomes, and periodically reports a suite of perinatal indicators (16). The independent health organization CIHI has also published comprehensively on hospital utilization patterns for childbirth using the DAD (15, 23, 25, 31, 103). Relative to provincial/territorial databases and hospital records, nation-wide data sources are more limited in coverage. They also lack consistency and variety of variables collected across the country. Due in part to privacy concerns and the need for provincial-level buy-in, records linkage at the national level is really at its infancy.

2.4 SES and Hospital Utilization for Delivery

While research on SES and health care use is vast, the association between SES and hospital utilization has not been thoroughly reviewed. Poorer individuals with fewer resources might need more health care services in order to achieve and maintain good health. However, with hospital utilization being a distal and indirect outcome of income status, as well as conditioned by many social, political, and biological differences, it comes as no surprise that the relationship between SES and health care utilization is inconsistent in the literature.

In order to carry out such an assessment systematically, it is necessary to narrow our focus on SES and hospitalization in the context of specific health outcomes, diagnoses, or populations. Childbirth represents an integral and conveniently routine health care event covered under Canada's public health care system. In theory, no gaps should exist in service provision for childbirth nationally. In the following section, I review the literature representing the key studies linking income as a measure of SES to hospital utilization measures for childbirth – specifically, LOS and readmissions.

KEY STUDIES LINKING SES TO HOSPITAL UTILIZATION FOR CHILDBIRTH

Many studies have examined the relationship between income and childbirth outcomes, but fewer have studied whether hospital utilization related to delivery is socioeconomically patterned by income. A brief description of how I conducted the literature review assessing this relationship follows.

I employed two database search engines (Web of Knowledge, PubMed) to find relevant studies using four elements in my search strategy: income, childbirth, hospital utilization, and the Canadian population. Keywords associated with the four elements were sought anywhere in the record. My main exposure of interest was income. In order to capture studies that used income-related measures of SES, I used both the narrow search term "income" as well as broader related search terms. "Birth" was the single term used to capture studies relating to childbirth and delivery. I included both general words related to hospital utilization, as well as two traditional utilization measures of particular relevance to this study, "length of stay" and "readmission" in order to capture utilization related and proximal to the specific health care interaction for delivery, as well as provide a means of comparison between studies.

Figure 1 is summary of the search strategy and the results. A total of 277 papers were retrieved. Selection of papers to include in the review were based on whether the authors had reported potential associations between income or income-related measures and hospital utilization, and if the hospital utilization reported was for, or closely related to, the delivery event itself. One hundred and sixty (160) studies were identified by title review as being unrelated to childbirth, SES, and/or hospital utilization. Thirty-one (31) studies were not conducted in Canada, and were excluded at the outset. Remaining studies were then assessed based on whether they investigate the relationship between income-related SES and hospitalization for or related to childbirth.

Excluded studies included those with non-income related exposure variables, those not examining hospital utilization metrics, those measuring long-term childhood or maternal hospitalization distal from the delivery itself by one year, studies examining acceptance of prenatal care, and those restricted to specific interventions, or subpopulations with no variation in SES or utilization.

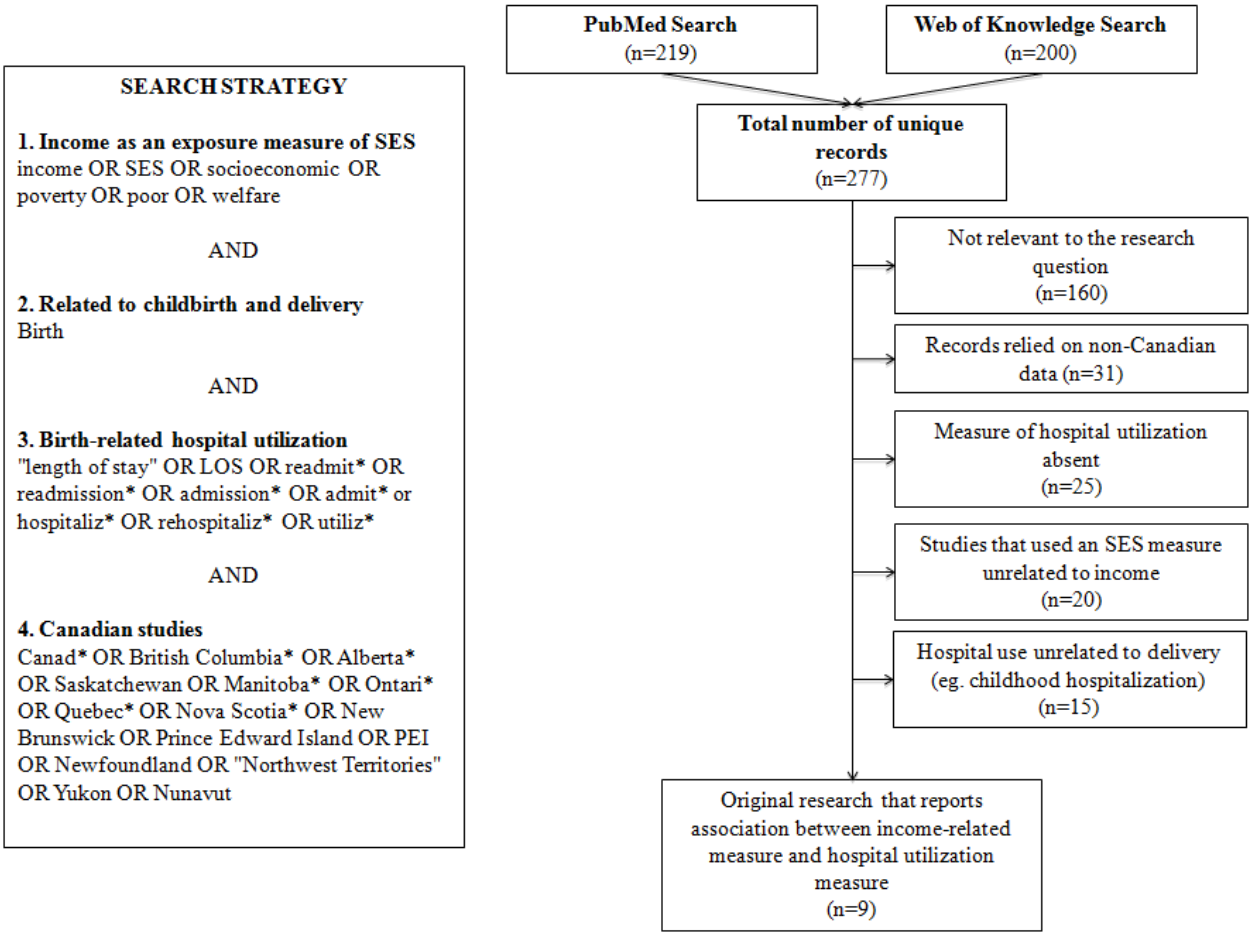

Figure 1. Literature review search strategy for papers linking income-related SES measures to hospital utilization.

A total of nine original research articles reported an association between an income-related exposure, and a delivery-related hospital utilization measure. Three studies (155-157) used data from defined hospital sites, and the rest utilized population-based administrative health care data. Four studies were conducted in Ontario, two in Alberta, two in Manitoba, and one in Quebec. In

contrast to studies assessing the relationship between income and adverse birth outcomes, I did not find any studies with hospital utilization as the outcome measure carried out at the national level. Sample sizes ranged from 165 births (157) to 189,586 live births over seven years (21). A variety of different income measures were used, and included welfare or social support as the primary source of income, income or area-based income, and one study used income adequacy with regard to Statistics Canada's Low Income Threshold (158). Martens et al. (19) used composite measures of SES that included income. Four studies used area-based income as a proxy measure, while one used income groupings based on individual-level income (157).

The hospital utilization measure most commonly used was rates of neonatal admission within the perinatal period, followed by hospitalization rates that extended past four weeks postpartum. A single study (159) analyzed both 28-day readmissions and early readmission within six days of delivery. Other measures included admission to the neonatal intensive care unit (NICU), early discharge after delivery (155) and composite usage or costs based on number of postpartum visits. A single study examined maternal readmission (157). Interestingly, while some studies had reported delivery LOS (21, 157, 159), none attempted to model LOS as an outcome measure of utilization. Furthermore, no studies examined the hospital utilization in the period immediately before birth. One study relied on self-reported post-partum health care use (155), while the rest utilized administrative data.

In general, patterns of health care use for delivery by income status are much weaker than the patterns seen in adverse birth outcomes themselves. Seven of the nine studies reported differences in hospital utilization by women's income status, however the nature and degree to which these groups were different was variable. Some studies determined low income as a principal predictor of higher infant readmission even after adjustment for multiple covariates (19,

20, 156, 158), and some detected more subtle or negligible differences in utilization (21, 159, 160). Two studies reported no difference in usage between different SES groups (155, 157), and one study did not report what the null association was between family income and volume of postpartum hospital visits (157). One study detected lower utilization for the lowest income groups in the form of earlier discharge from hospital after delivery (155). Another determined that infants from families with moderately inadequate household incomes had higher rates of readmission than those from adequately financed families, and the lowest income group had the lowest likelihood of admission over a 5-month postpartum period (158). The evidence suggests health problems associated with lower SES can cause the poor to be at risk of using the healthcare system more often. At the same time, low-income women may underutilize the healthcare system because of barriers related to poverty. For example, the poor may not be able to access healthcare as often because they lack resources to be able to take time off work, or they may lack transportation to get to a hospital. Beyond health care for childbirth, access to primary care may be insufficient, and some studies have seen children in very low-income groups exhibit lower hospitalization rates (161), suggesting the need for evaluating pediatric primary care.

The number and ways in which covariates were taken into account also differed across studies. All studies (except for one) controlled for potential confounders in measuring the association between income and hospital utilization (155). The most common variables accounted for were maternal factors such as age, marital status, and Aboriginal status and parity, infant characteristics such as sex, birth weight, and gestational age, pregnancy details such as mode of delivery, labour induction, and LOS, as well as area-based characteristics such as rural residence. Four studies focused on specific infant groups and their interaction with income-related indicators. These included PTB (20), LBW (21), complex chronic conditions (162), and those

admitted to the neonatal intensive care unit (NICU) (157). Ruth et al. (20) found higher readmissions for lower-income infants independently of gestational age, while Wang et al. (160) reported absolute hospitalization risk differences attributable to SES were much higher among infants with complex chronic conditions than those without. Thanh et al. (21) reported considerable overlap between low-income status and LBW, but found little difference in utilization outcomes among income groups. Although this review was restricted to Canada, similar mixed trends leaning toward an inverse relationship between income and hospital use have been found in the US (163, 164) as well as internationally (165, 166). These mixed results are unsurprising given the association between income and hospital utilization is sensitive to variations in individual demographics and area-based differences, in addition to health policy and the presence of universal health insurance.

In evaluating whether the shift towards shorter LOS after delivery leads to increases in neonatal readmission (32), two studies included in this review addressed this question and did not necessarily find LOS to be a significant predictor of neonatal readmission (156, 159). There was indication, however, that readmission rates tended to be highly variable between hospital sites (156). One study found LOS was a predictor of early neonate readmissions within 6 days of discharge for delivery, but not all readmissions within 28 days (159). Another point of interest that became clear upon conducting this review was the importance of longitudinal studies on child and maternal health in the years after delivery. Two Canadian studies in particular were not included in the review (161, 167) due to their focus on childhood hospitalization. They found that poverty and low-income status were associated with higher hospitalization rates throughout early childhood – a trend that has also been seen internationally (168). This illustrates the potential limitation of research restricted to the perinatal time period to detect SES differences

among patients that are shaped by delivery. However, assessing the resource costs of universal care for childbirth and delivery as standard health care practice is a crucial aspect shaping maternal health and child development, and can serve to inform policy as to the health and SES of the population in a universal health care setting.

OBJECTIVE

There is considerable interest in investigating utilization differences among individuals of different SES and demographics. In Canada's universal health care setting, where access to obstetric services is publicly covered and there is at least some standardized practice, I ask whether we see patterning in hospital utilization for childbirth by income.

Of the two socioeconomic variables available in these data (income and maternal educational attainment), I selected income as the main exposure of interest for several reasons. Although income is susceptible to greater fluctuation, it is a more direct measure of access to material resources at any given time, whereas a higher education level may not necessarily mean greater material resources that could be associated with well-supported pregnancy (e.g., adequate diet, reduced stress/worry associated with the costs of child-rearing). My goal was to address income as an aspect of women's access to maternal resources at a critical time for maternal and child health. Income would also apply to all women giving birth regardless of age, whereas maternal education would not apply to the subset of women giving birth as adolescents.

In Canada, links have been established between individual level determinants of health and adverse birth outcomes, usually at a regional or provincial level. Fewer studies have looked comprehensively at whether these individual-level factors are associated with differences in the volume of hospital utilization. In order to broaden the view beyond utilization that occurs only at the time of delivery, I examined the risk of maternal readmission within 30 days of discharge for

delivery, and the risk of prenatal hospitalization within 30 days prior to admission for delivery in addition to LOS for delivery.

In Canada's universal health care setting, I predict that low-income women will have higher hospital utilization for delivery, as measured by LOS, prenatal admission and post-partum readmission. While I acknowledge the relationship between SES and health care usage is not directly causal, examining utilization patterns for standard medical procedures such as delivery in the context of individual-level SES is useful from an economic and health policy perspective, and could give us insight into the potential costs of poverty in Canada.

This study will:

- Characterize a population-based sample of women who gave birth in Canada between 2005 and 2009, and were also respondents to a national health survey that had agreed to link and share their information
- Evaluate the association between individual-level household income and hospital utilization related to childbirth
- Examine and account for other individual-level socio-demographic and clinical risk factors that may also be associated with hospital utilization.

CHAPTER 3: METHODS

This descriptive study employs data from a national cross-sectional survey linked with administrative hospital-based data to characterize utilization volume and patterns of women giving birth in hospital. My goal was to investigate how these patterns differ among women of different SES based on a variety of self-reported factors, primarily with respect to income.

3.1 Linked Data Sources

I utilized a pilot linkage of the Canadian Community Health Survey (CCHS) and the Discharge Abstract Database (DAD). These are two national data sources maintained by Statistics Canada in collaboration with the Canadian Institute for Health Information (CIHI). The CCHS is a repeated cross-sectional survey that collects self-reported information related to health status, behaviors and conditions from the Canadian population. Every two years, a sample of 130,000 Canadians who are 12 years of age or older are drawn from the Canadian population. Importantly, the survey's coverage excludes those living on reserves and other Aboriginal settlements, full-time members of the Canadian Forces, institutionalized individuals, and those living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James (169).

LOS information for delivery-related hospital visits was extracted from the DAD, an administrative hospital database that records all separations from Canadian acute care institutions. Acute care hospitals keep provincially standardized hospital charts and records, but also submit abstracts with key requested fields to the Canadian Institute of Health Information (CIHI) for incorporation into the DAD. The DAD includes discharges, deaths, sign-outs, and transfers, and contains administrative, clinical, and limited demographic data. Clinical data is

recorded using the Tenth Canadian revision of the International Classification of Diseases and related Health Problems (ICD-10-CA), which can be used to identify which admissions were related to birth events, as well as those related to pregnancy and perinatal complications.

Records were both deterministically and probabilistically linked and validated by Statistics Canada using a process described in detail elsewhere (170, 171). There was no agreement to include records from Quebec in this federal data linkage initiative and so this analysis excludes Quebec entirely. Probabilistic linkage was carried out using the Generalized Record Linkage Software (GLRS) and G-LINK (172) system developed by Statistics Canada, using the degree of agreement on five fields: date of birth, sex, postal code, province issuing health information number (HIN) and the HIN of patients. A score is assigned based on the quality and degree of similarity between each variable in a given record, with different weights assigned to each variable. For instance, a match on a multi-digit HIN is more difficult than a match to a dichotomous indicator like sex. Hence, greater weight is placed on a HIN match. These scores for each of the five variables are then summed for each proposed linked pair of records in the CCHS and DAD, and this is called the "total linkage weight." A higher total linkage weight for a given CCHS-DAD pair indicates higher likelihood that the records match, and belong to the same individual. Probabilistic records linkage enables us to set a threshold value for total linkage weights to permit the inclusion of links based on incomplete or imperfect information, which is a common characteristic of administrative databases.

3.2 Study Sample

Our population of interest was females who had a singleton delivery in Canada (excluding Quebec) between 2005 and 2009. From the linked CCHS survey and administrative DAD data, qualifying individuals connected with hospital discharge abstracts were selected based on

delivery-related ICD-10-CA codes in the primary diagnostic position for those CCHS respondents who agreed to share and link their information. ICD-10-CA codes were chosen based on a previous selection of diagnoses (173) which identify discharges that involved a delivery resulting in a live birth. These included diagnosis codes related to delivery of a live singleton (Appendix, Table 12). These delivery-related ICD-10-CA codes were cross-validated with CIHI's Canadian Case Mix Group (CMG) classification for birth and delivery-related interventions, where there was 100% agreement. 7,988 delivery-related discharge abstracts from 6,218 unique individuals had codes related to delivery of a singleton infant. As this is a preliminary records linkage of these two databases, there is considerable potential for low probability links. Therefore, I elected to take a conservative approach in our use of the linked dataset, and excluded all individuals bearing a delivery-related discharge who were listed as "male" in the CCHS, and/or had a mismatched or incomplete date of birth, as these elements were key variables in the linkage process. The eligible sample contained 7,628 births in hospital from 5,931 individual women. After removal of those with missing data (primarily non-responders to household income), the final sample available for complete case analysis was 7,163 deliveries attributed to 5,568 women (Figure 2).

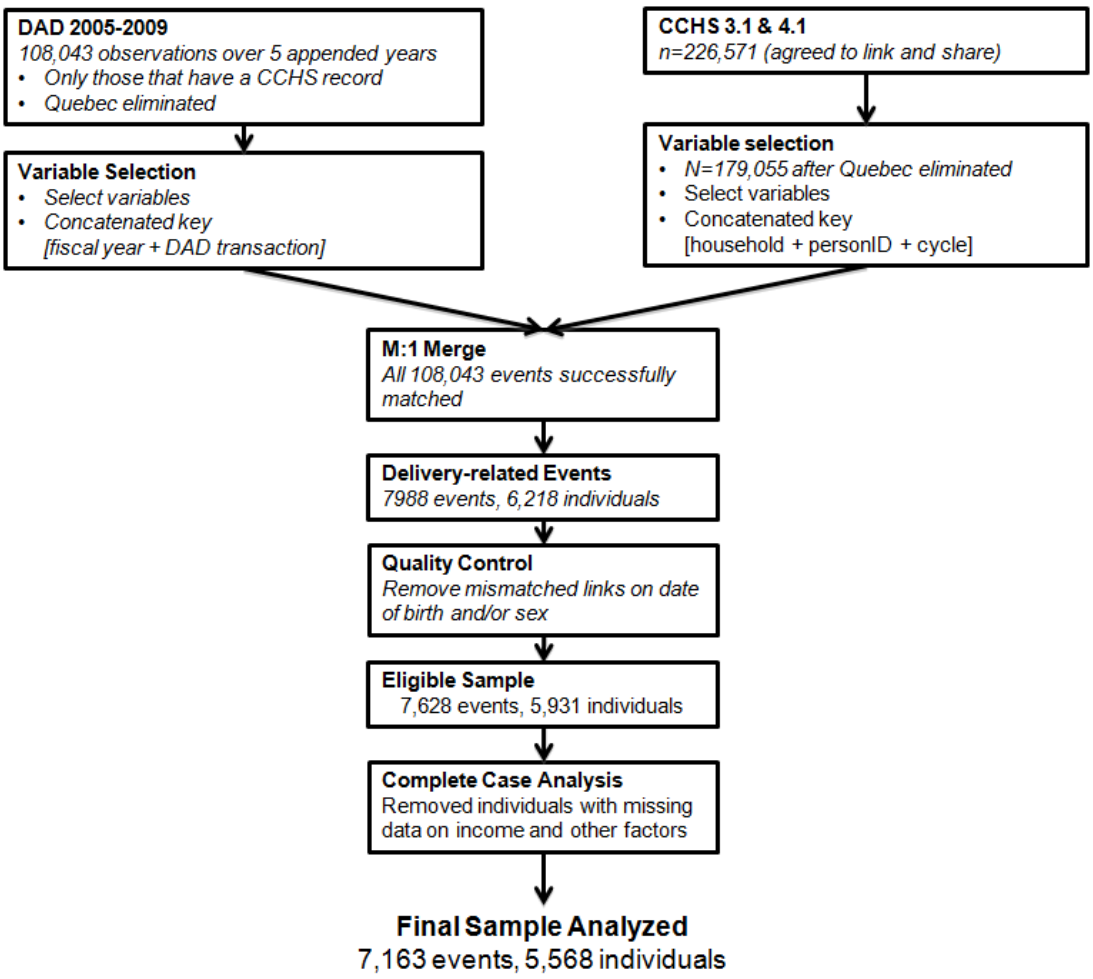

Figure 2. Sample selection for CCHS respondents who gave birth in hospital between 2005 and 2009, and agreed to link and share their information.

3.3 Data Elements

Outcome variables. The three outcomes of interest were total LOS as reported in the DAD, readmission within 30 days of hospital visit for delivery, and admission within 30 days preceding delivery. The DAD provides a continuous variable for LOS, measured in days.

"Maternal readmission" was defined as a readmission occurring within 30 days after the hospital delivery for the mother. While the DAD has a readmission field, regional health authorities and whole provinces collect this data inconsistently. Furthermore, it would be impossible for a discharge abstract for delivery to denote the occurrence of a readmission posterior to the

delivery. Since there is no variable in the DAD that consistently identifies whether a hospital visit had been preceded by a hospital visit for delivery, an indicator variable (yes or no) was generated (Figure 3). All hospital visits from the sample were ordered by patient and then admission date, and assigned a "yes" for readmission if the next adjacent hospital-visit after delivery occurred within 30 days.

"Pre-delivery admission" was defined as an admission occurring within 30 days before delivery in hospital. Similar to the challenges posed by administrative data collection inconsistencies for the post-delivery readmissions variable, delivery events themselves are inconsistently marked as having occurred within 30 days of an antecedent hospital visit. Therefore, the same method of ordering all hospital visits from the data set by patient then admission date, and assigning a "yes" for pre-delivery admission if the adjacent hospital visit before delivery occurred within 30 days was used (Figure 3).

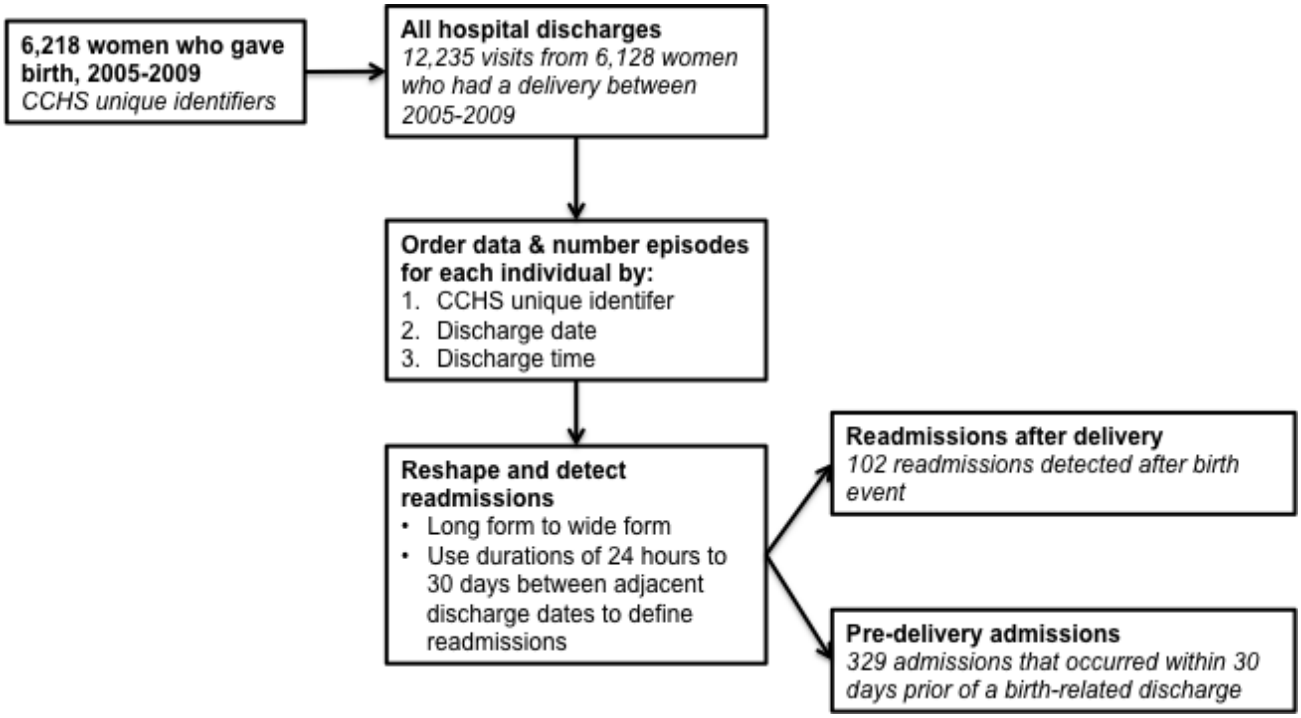

Figure 3 Detecting admissions adjacent to hospital delivery within 30 days.

Independent variables. The primary exposure of interest was socioeconomic status as measured by total household income from all sources. The 12-level variable collected in the CCHS was used to derive a three-level income variable using a dose-response approach. The goal was to evaluate the relationship between income and hospital use, and see if optimal contrasts existed between LOS days and income groups.

Other covariates were selected based on previous evidence of association with adverse maternal health and birth outcomes, which could translate to differential hospital burden. These individual-level factors included urban/rural residence, province, immigrant status, and marital status. Delivery-specific factors I accounted for included maternal age at delivery, fiscal year, mode of delivery, and nulliparity.

In order to understand the role of maternal education in birth-related hospitalization, a parallel sub-analysis using the education variable was conducted on the subset of women who were 25 years of age or older. The variable would not apply to the younger and adolescent fraction of the study population, as these individuals would never have had the opportunity to attain post-secondary education or degrees at their age. A four-level CCHS variable for the respondent's highest level of education attained was collapsed into a three-level variable, which included women with less than high school graduation, those with high school graduation or some post-secondary education, and those graduated with a post-secondary diploma or degree.

CCHS variables for area of residence (urban = 0, rural = 1), Aboriginal status (0=Non-Aboriginal, 1=Aboriginal), and immigrant status (0 = non-immigrant, 1 = immigrant) were used in the analysis without further modification or recoding. Marital status was recorded as a multi-level variable in the CCHS, and was collapsed into an indicator variable (partnered = 0, un-

partnered = 1). Province as reported in the DAD was also included, in addition to the fiscal DAD year in which the birth occurred in order to account for secular effects in hospital usage.

I adjusted for maternal age and nulliparity, which are known to impact LOS for delivery. Parity information is inconsistently collected in the DAD within and between health facilities, regions, and provinces/territories. An indicator variable for nulliparity (first birth = 1, subsequent birth = 0) was derived from a combination of variables in the DAD and the CCHS (Figure 4). A woman was considered nulliparous at a specific birth event if: a) she was noted as having zero previous live births in the DAD, b) if she was recorded in CCHS as having a living arrangement that had no children included, or c) she had no preceding births recorded in our linked DAD-CCHS dataset at hand. Maternal age in years at time of delivery was available as a continuous variable in both the CCHS and DAD. In order to provide a more meaningful contrast of LOS by age, the variable was rescaled in increments of 1 year to 5 years.

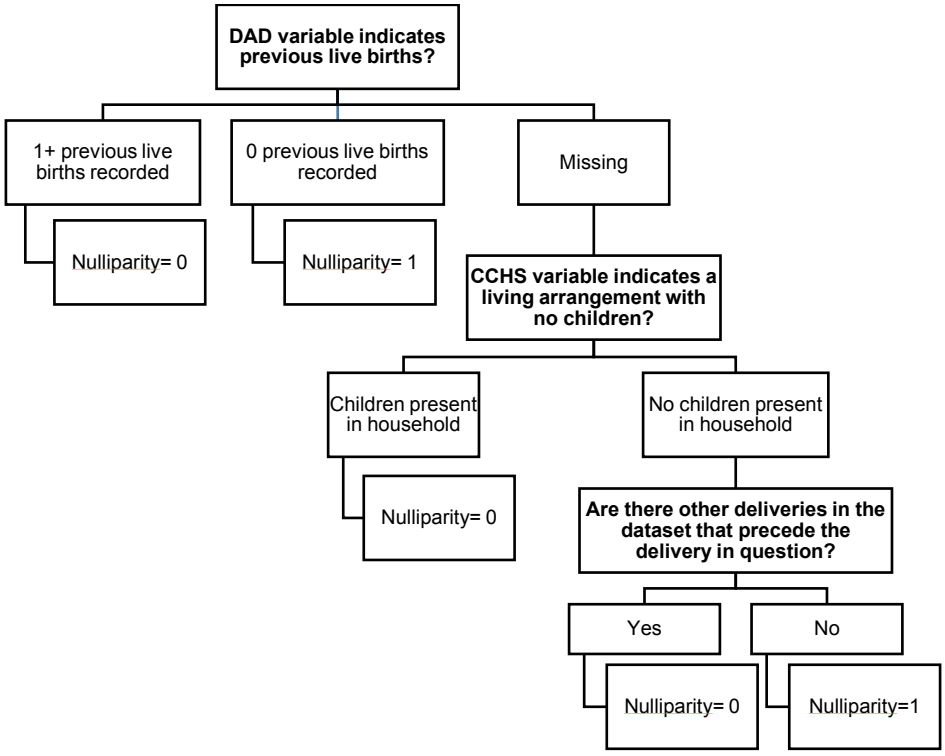

Figure 4 Flowchart for constructing a proxy variable for nulliparity.

Due to the major differences in hospital utilization and health implications presented by mode of delivery, I also controlled for whether the birth occurred vaginally or by Caesarian section. Deliveries were classified dichotomously (vaginal delivery = 0, Caesarian delivery = 1) using CIHI's CMG classification.

3.4 Statistical Analyses

Data. Linked data files were appended, merged, and analyzed using Stata version 12 (StataCorp LC, College Station, Tex). Access to the CCHS micro-data allowed for a pooled approach in combining survey and administrative data across different years. Descriptive statistics were generated for maternal characteristics, as well as delivery characteristics and initial bivariate associations by cross-tabulation. This study uses un-weighted survey data. I did not apply the survey sampling weights for two reasons. First, the goal was to assess the individual-level association between income and hospitalization, rather than assess population averages for low-income and hospitalization. Second, the absence of Quebec from the dataset necessarily meant the sample would not be nationally representative, but would still represent a multi-province/territory sample of survey-respondents who had given birth in 2005-2009.

Models. The three outcome variables (LOS, risk of maternal readmission, and pre-delivery admission) were modeled using univariate and multivariable regression models. LOS was modeled as a count variable using negative binomial regression due to over-dispersion commonly observed in hospital count data. Risk of admission within 30 days prior and subsequent to a hospital visit for delivery were modeled using logistic regression. For all models, we used robust and clustered standard errors (clustered by the unique patient identifier) in order to account for the presence of multiple deliveries from a single woman.

Covariates. Canada has a universal health care system, and women giving birth are entitled to the same basic obstetric services and resources, regardless of the province or territory she resides. Including province/territory in the regression models could overwhelm the effects of covariant socioeconomic variables such as Aboriginal status, or urban/rural residence. Additionally, income and costs of living differ regionally. In order to reflect both Canadian (excluding Quebec) and regional dimensions of variations in hospital use, regression models were run taking an incremental approach. Models were first run without province/territory, and subsequently added in later models. Five individual-level socioeconomic variables consisting of household income adjusted for household size, Aboriginal status, immigrant status, rural/urban residence, marital status, as well as maternal age, nulliparity, delivery mode, and fiscal year were selected a priori for inclusion in the regression models, based on their relevance to the relationship between socioeconomic status and hospital utilization for delivery in the literature. An interaction term between Aboriginal status and rural/urban residence was also tested for every model. Lastly, a subgroup analysis was conducted for women aged 25-55 years, and included maternal educational attainment to account for potential confounding of the effect of income by maternal education.

CHAPTER 4: RESULTS

4.1 Maternal characteristics and deliveries in Canada

The average LOS for the entire sample between 2005 and 2009 was 2.61 days, with the longest LOS lasting 87 days. The average LOS for deliveries declined over time from 2.73 days in 2005 to 2.42 days by 2009. Delivery by C-section accounted for 27.17% of live singleton births, a percentage consistent with that reported in a national analysis using all DAD delivery data between 2001 and 2009 (18). Both maternal readmissions within 30 days of discharge from a hospital visit for delivery and maternal admission within 30 days prior to admission for delivery were uncommon, taking place in 1.33% and 4.38% of all deliveries, respectively. There are relatively balanced proportions of deliveries from each available year of hospital data. The predominant diagnoses upon maternal readmission (Figure 5) were postpartum hemorrhage and infection. False labour, classified as a complication relating to the fetus and the amniotic cavity, was the main reason for admission within 30 days before delivery (Figure 6), followed by gestational hypertension and preterm labour.

Table 1. Delivery characteristics of all eligible hospital births.

		Average LOS (days)	**Percent of all deliveries in the sample (%)**
Total number of deliveries (7,628)		2.61	100.00
Year	2005	2.73	21.01
	2006	2.67	20.99
	2007	2.64	20.79
	2008	2.59	18.94
	2009	2.42	18.26
Mode of delivery	Vaginal	2.15	72.83
	C-section	3.86	27.17
Maternal Readmission *Within 30 days of discharge for delivery*	Yes	3.83	1.33
	No	2.60	
Pre-delivery Admission *Within 30 days of admission for delivery*	Yes	3.47	4.38
	No	2.58	

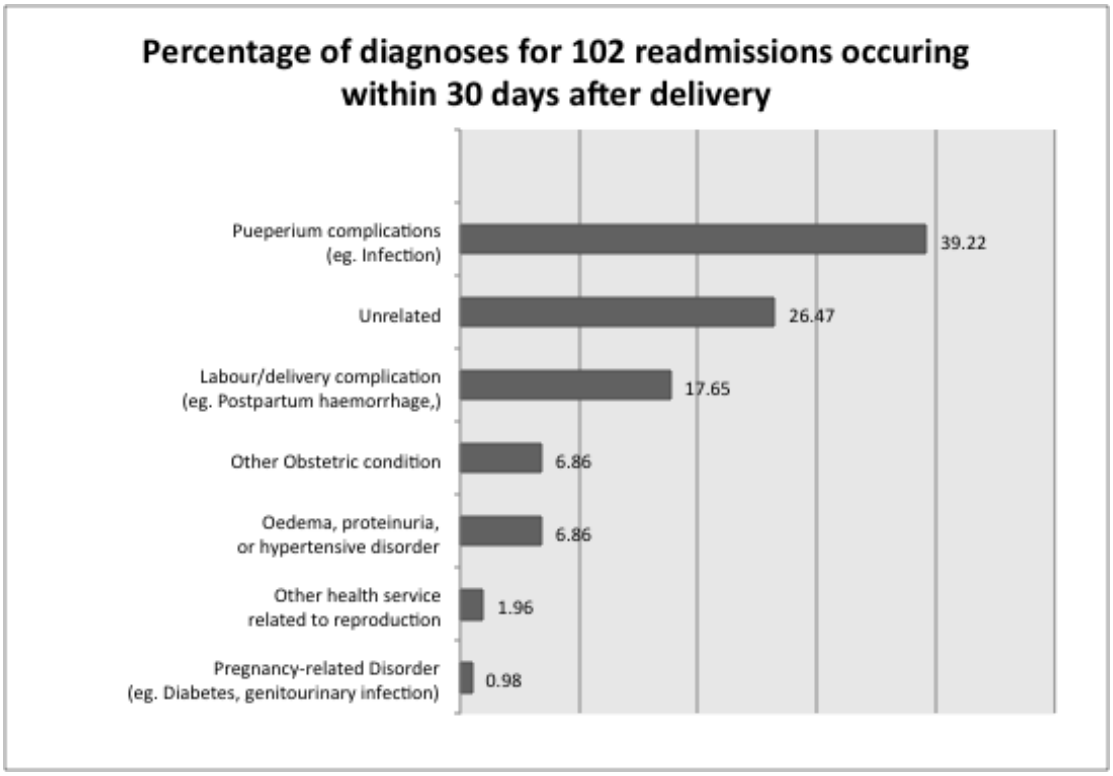

Figure 5. Diagnostic reasons for readmission to the hospital between 24 hours and 30 days after delivery in hospital.

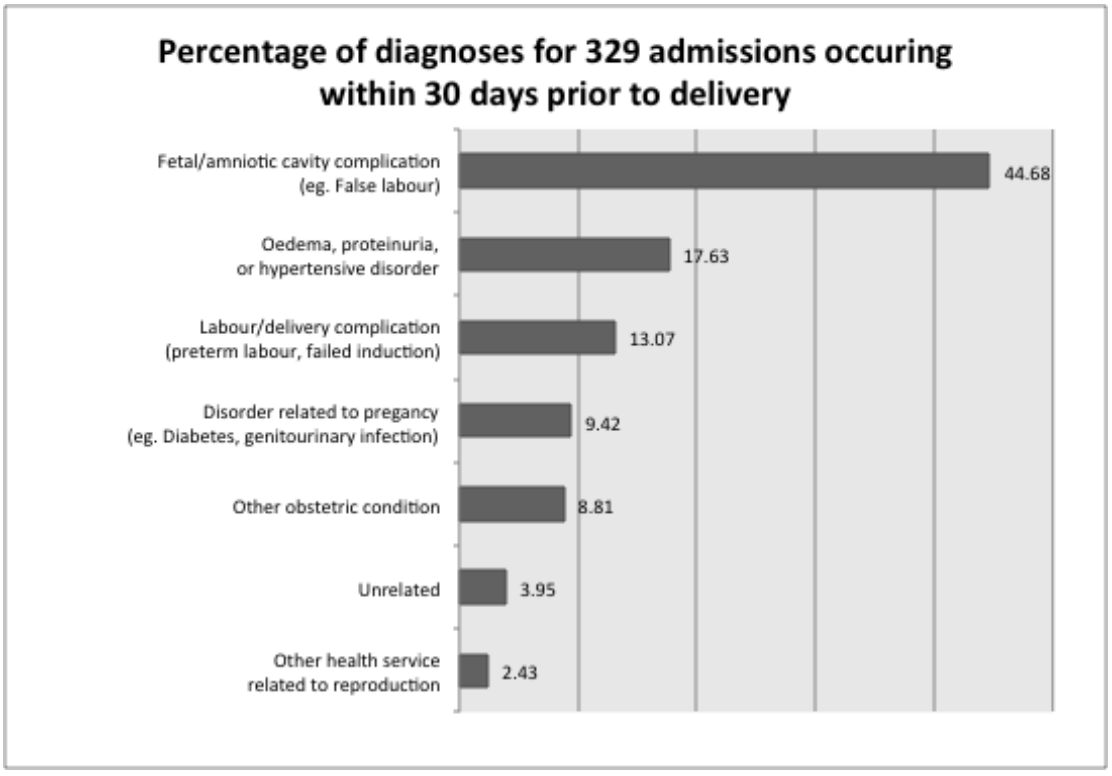

Figure 6. Diagnostic reasons for admission to the hospital between 24 hours and 30 days prior to delivery in hospital.

Between 2005 and 2009, 5,931 Canadian women who gave birth in hospital had also been CCHS respondents that agreed to link and share their survey data between 2006 and 2008 (Table 2). The average age of first delivery recorded in the dataset was 28.9 years, and a first-time pregnancy was recorded for 37.8% of women. Approximately 5% of the sample were teenagers at the time of delivery, while 19% were 35 years of age or older. The largest fraction of the sample came from Ontario (just under 40%). The fewest women came from the Yukon (under 1%). In order to assess the potential bias that could result from women who did not report income, characteristics of those missing income data were compared with the rest of the sample (Table 3). 5.77% of the sample did not report income, and were more likely to be adolescent girls, less educated, un-partnered, and to a lesser extent, tended to be white, and live in a rural area. Other individual level characteristics and hospital utilization were present in similar proportions between those with and without income data. A particularly prominent characteristic of the study population was that adolescent pregnancies in Aboriginal girls (14.37%) out-numbered those in non-Aboriginal girls (3.07%) by over four-fold (Table 4).

Table 2. Maternal characteristics of eligible women, including those with missing data.

	n = 5,931	Frequency	Percent of sample
Maternal age	=<19	295	4.97
	20-34	4,676	78.84
	>=35	960	19.19
Income	<$30,000	1,111	18.73
	$30,000-49,999	1054	17.78
	$50,000+	3,424	57.73
	Not stated	342	5.77
Education	Less than high school	678	11.43
	At least high school graduation	1481	24.97
	Post-secondary graduation	3763	63.45
	Not stated	9	0.15
Aboriginal Status	Aboriginal	616	10.39
	Non-Aboriginal	5,300	89.34
	Not Stated	16	0.27
Residence	Urban	4,513	76.09
	Rural	1,418	23.91
Marital Status	Partnered	4,333	73.09
	Not Partnered	1,595	26.91
Immigrant Status	Non-immigrant	5,193	87.59
	Immigrant	736	12.41
Province of residence	Ontario	2361	39.81
	Newfoundland/Labrador	226	3.81
	PEI	126	2.12
	Nova Scotia	261	4.40
	New Brunswick	283	4.77
	Manitoba	480	8.09
	Saskatchewan	534	9.00
	Alberta	718	12.11
	British Columbia	687	11.58
	Yukon	52	0.88
	Northwest Territories	93	1.57
	Nunavut	110	1.85

Table 3. A comparison of characteristics between the full sample and women with missing income data.

		Percent in full eligible sample n=5,931	Percent in women with missing income n=342
Age group	=<19	4.97	14.62
	20-34	78.84	77.49
	>=35	16.19	7.89
Education	Less than secondary	10.35	29.76
	Secondary graduation	24.51	33.33
	Post-secondary graduation	63.15	36.90
Marital Status	Partnered	74.51	53.15
	Not partnered	25.49	46.85
Aboriginal	Aboriginal	9.97	17.75
	Non-aboriginal	90.03	82.25
Residence	Urban	23.91	35.96
	Rural	76.09	64.04
Immigrant	Non-immigrant	87.59	85.88
	Immigrant	12.41	14.12

Table 4. Proportion of pregnancies by maternal age among Aboriginal and non-Aboriginal women.

Age Group	Non-Aboriginal (%)	Aboriginal (%)	Total (%)
<=19	3.07	14.37	4.31
20-34	79.75	77.25	79.48
35+	17.17	8.38	16.21
	100	100	100

4.2 Association between income and childbirth hospital burden

A dose-response analysis was performed to derive a 3-level income variable from the 12-level income variable in the CCHS. Categories were based on differences in the predicted LOS "response" for each successive income "dose" category. After the negative binomial regression for LOS in days on income adjusted for household size, marginal predicted LOS for each group was determined, and contrasts between adjacent groups were plotted. Deviation from "0" on the Y-axis, representing the predicted difference in LOS in days between two adjacent groups, indicates greater difference between those groups. Few contrasts could be seen between income ranges, aside from a larger imprecise difference between those with no income and less than $5,000 annual household income. Income ranges 0-29,999$ (low), 30,000-49,999$ (medium), and 50,000$ or more (high) had small differences in predicted length of stay, but made more substantive sense in the Canadian context. The original 12-level variable was collapsed into these three categories (Figure 7).

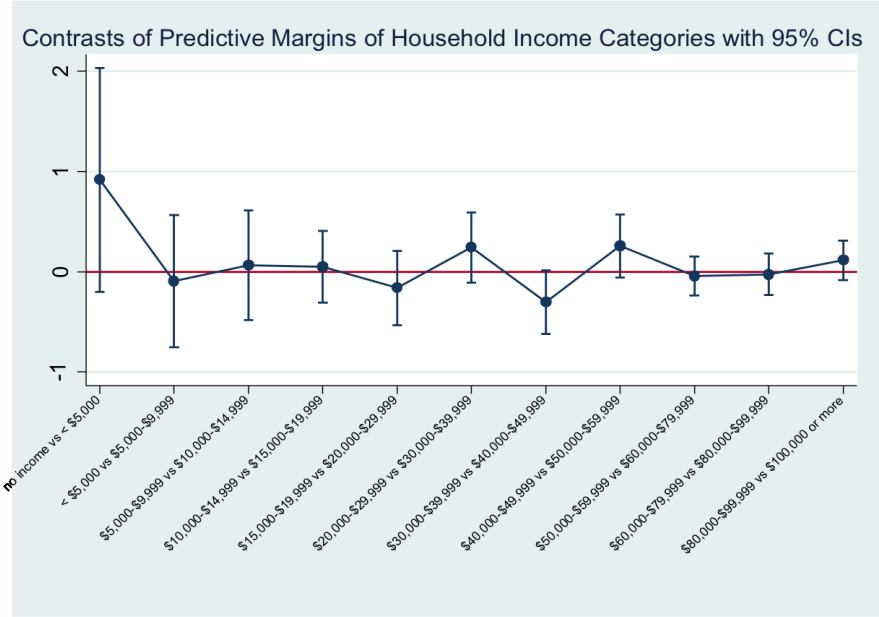

Figure 7. Dose-response analysis to determine income categories used in regressions. The y-axis represents contrasts of predicted differences in the LOS days between each income group.

Using these income categories in models of LOS and maternal admissions, minor income gradients of decreased LOS by increasing income level were observed in both univariate and multivariate analyses for aspects of hospital utilization examined in this study (Table 5).

Both before and after adjusting for other covariates, the association between household income and delivery LOS displayed a modest gradient of increasing LOS with decreasing income. After adjusting for all covariates, incidence rate ratios (IRRs) indicate those in the lowest and middle-income categories had an 8% and 3% higher predicted LOS than those in the highest income category, respectively. IRRs were translated to a predicted LOS of 2.76 days [2.61, 2.92] in the lowest income group after adjustment for covariates and provincial fixed effects, which is slightly longer than that of both the middle and highest income groups at 2.63 days [2.50, 2.76] and 2.56 days [2.49, 2.63], respectively.

Slight socioeconomic patterning between the highest and lowest income groups was also detected in the odds ratios of surrounding admissions within 30 days of admission or discharge for delivery. However, these differences were negligible in considering the predicted probabilities of either admission type, and this was due to the relatively low readmission rates of the sample, which is also true of the general population. Maternal readmissions exhibited higher readmission in the lowest as compared to the highest income groups, with the middle-income group exhibiting the lowest maternal readmission rate. The odds ratio for the risk of maternal readmission for the lowest income group as compared to the highest income group was 1.26 [95% CI = 0.78, 2.04], which indicated a roughly 0.5% difference in the predicted probabilities of readmission between each group, and this estimate did not change very much but decreased in precision somewhat after adjusting for other factors (OR=1.38 [0.74, 2.57]) as well as provincial effects (OR=1.40 [0.62, 3.17]). For pre-delivery admissions, a more consistent but imprecise gradient was found with slightly increasing admissions from high to medium income groups

(OR=1.19 [0.88, 1.61]), and high to low-income groups (OR=1.53 [1.16, 2.02]). However, this gradient did not persist after adjusting for other factors. Adjusting for provincial fixed effects did not appear to change the relative relationship between income categories much, but changed the estimates somewhat for maternal admissions.

Table 5. Summary of regression results for association between household income and hospital utilization.

	Length of Stay					
	Unadjusted		Adjusted without provincial fixed effects		Adjusted with provincial fixed effects	
	IRR [95%CI]	Predicted LOS (days) [95%CI]	IRR [95%CI]	Predicted LOS (days) [95%CI]	IRR [95%CI]	Predicted LOS (days) [95%CI]
High	1.00	2.57 [2.50, 2.64]	1.00	2.54 [2.47, 2.61]	1.00	2.56 [2.49, 2.63]
Middle	1.04 [0.97, 1.10]	2.66 [2.51, 2.82]	1.05 [0.99, 1.11]	2.66 [2.53, 2.79]	1.03 [0.97, 1.09]	2.63 [2.50, 2.76]
Low	1.04 [0.98, 1.11]	2.68 [2.52, 2.84]	1.10 [1.03, 1.17]	2.80 [2.64, 2.96]	1.08 [1.01, 1.15]	2.76 [2.61, 2.92]
	Risk of Maternal Readmission within 30 days after discharge for delivery					
	Unadjusted		Adjusted without provincial fixed effects		Adjusted with provincial fixed effects	
	OR [95%CI]	% Predicted probability [95%CI]	OR [95%CI]	% Predicted probability [95%CI]	OR [95%CI]	% Predicted probability [95%CI]
High	1.00	1.31 [0.96, 1.65]	1.00	1.27 [0.92, 1.63]	1.00	1.32 [0.95, 1.68]
Middle	0.74 [0.40, 1.36]	0.97 [0.45, 1.49]	0.78 [0.42, 1.46]	1.00 [0.45, 1.54]	0.89 [0.54, 1.49]	1.18 [0.72, 1.64]
Low	1.26 [0.78, 2.04]	1.64 [0.99, 2.29]	1.38 [0.74, 2.57]	1.74 [0.89, 2.60]	1.40 [0.62, 3.17]	1.83 [0.55, 3.12]
	Risk of Maternal admission within 30 days prior to admission for delivery					
	Unadjusted		Adjusted without provincial fixed effects		Adjusted with provincial fixed effects	
	OR [95%CI]	% Predicted probability [95%CI]	OR [95%CI]	% Predicted probability [95%CI]	OR [95%CI]	% Predicted probability [95%CI]
High	1.00	3.77 [3.20, 4.33]	1.00	3.88 [3.26, 4.49]	1.00	4.00 [3.37, 4.63]
Middle	1.19 [0.88, 1.61]	4.45 [3.35, 5.56]	1.14 [0.83, 1.56]	4.39 [3.29, 5.49]	1.07 [0.78, 1.47]	4.27 [3.19, 5.34]
Low	1.53 [1.16, 2.02]	5.64 [4.41, 6.88]	1.38 [0.99, 1.94]	5.27 [3.93, 6.61]	1.26 [0.90, 1.77]	4.95 [3.74, 6.22]

A sub-analysis was performed for women aged 25 years and older, for which the education variable would apply (Table 6). The inclusion of maternal education further attenuated the subtle income patterns observed in the full sample, particularly for risk of maternal readmission and pre-delivery admission after adjustment. Similarly negligible differences are seen for LOS for delivery in both the full and sub-sample, however the contrast between highest and lowest income groups were marginally strengthened but less precise for readmissions for this sub-population at an odds ratio of 1.64 [0.95, 2.82], and was attenuated after adjustment as well for the sub-population (OR=1.30 [0.56, 3.57]. Income patterns in risk of pre-delivery admissions for women over 25 years of age were absent, in contrast to that seen for the full sample. Maternal education appeared to pattern pre-delivery admissions to a small degree before adjustment for other factors, with an odds ratio of 1.45 [0.85, 2.47] between the lowest and highest education groups, and 1.26 [0.91, 1.75] between the middle and highest education groups. However, this trend did not persist with adjustment for other covariates.

Table 6. Predicted LOS days and risk of admissions by income and maternal educational attainment, in women 25 years of age or older at time of delivery.

	Length of stay (days)							
	Unadjusted				**Adjusted (including provincial fixed effects)**			
	IRR	p-value	Upper 95% CI	Lower 95% CI	IRR	p-value	Upper 95% CI	Lower 95% CI
Income								
High	1.00				1.00			
Medium	1.05	0.21	0.97	1.14	1.02	0.57	0.95	1.09
Low	1.06	0.25	0.96	1.16	1.04	0.39	0.95	1.13
Maternal Education								
High	1.00				1.00			
Medium	1.06	0.13	0.98	1.15	1.08	0.03	1.01	1.15
Low	0.94	0.39	0.82	1.08	1.04	0.59	0.90	1.21
	Maternal readmission within 30 days of delivery discharge							
	Unadjusted				**Adjusted (including provincial fixed effects)**			
	OR	p-value	Upper 95% CI	Lower 95% CI	OR	p-value	Upper 95% CI	Lower 95% CI
Income								
High	1.00				1.00			
Medium	0.61	0.19	0.29	1.28	0.52	0.10	0.24	1.14
Low	1.64	0.08	0.95	2.82	1.30	0.50	0.60	2.78
Maternal Education								
High	1.00				1.00			
Medium	1.21	0.49	0.71	2.07	1.16	0.62	0.65	2.06
Low	1.60	0.28	0.68	3.72	1.42	0.46	0.56	3.57
	Maternal admission within 30 days of delivery admission							
	Unadjusted				**Adjusted (including provincial fixed effects)**			
	OR	p-value	Upper 95% CI	Lower 95% CI	OR	p-value	Upper 95% CI	Lower 95% CI
Income								
High	1.00				1.00			
Medium	1.10	0.60	0.77	1.58	1.00	0.99	0.68	1.46
Low	1.14	0.50	0.77	1.69	0.90	0.67	0.55	1.47
Maternal Education								
High	1.00				1.00			
Medium	1.26	0.17	0.91	1.75	1.16	0.41	0.82	1.65
Low	1.45	0.18	0.85	2.47	1.14	0.69	0.59	2.19

4.3 Other factors associated with hospital utilization for childbirth

Factors with the largest magnitude of association in all utilization measures were biologically driven, or intrinsic to hospitalization. These included mode of delivery, nulliparity, and province. Measures of association did not differ significantly between unadjusted and adjusted models, so results from the maximally adjusted model including provincial fixed effects are shown in Table 7. LOS for a nulliparous woman was predicted to be 31% longer than those having a past delivery. C-sections were associated with a 78% increase in LOS, which translates to a predicted 3.82-day stay for C-section births, compare to a 2.15-day stay for vaginal births. In contrast to the trend seen in nulliparity for LOS, there was a weaker and imprecise association between nulliparity and increased risk of readmission. What could be attributed to healthcare administrative variations was also a strong predictor of delivery LOS, namely province and fiscal year of delivery. Predicted LOS according to the adjusted model ranged from 2.33 [2.18, 2.49] in Alberta to 3.58 [3.07, 4.09] for a delivery in PEI (Table 8). Provincial differences in readmissions and prenatal admissions were substantial, but imprecisely estimated due to the limited number of these events in the dataset. While one might ask to what degree provincial effects are in fact, explained by differences in C-section rates, both factors persist as strong predictors even after inclusion in the same model. Moreover, provincial C-section rates are remarkably similar across provinces, as demonstrated in Table 13 Appendix.

Over the five years of study, an imprecise but discernible secular trend was seen in all three utilization outcomes, even after adjustment for individual-level factors (Table 9). LOS decreased by each consecutive DAD year from a predicted average of 2.79 days in 2005 to 2.38 days in 2009. Similarly, decreasing risk of pre-delivery admission within 30 days of admission for

delivery was seen with each progressive year of hospitalization data while a weaker, less consistent secular trend for risk maternal readmission was observed.

Table 7. Parity and mode of delivery are two of the strongest drivers of differential hospital utilization for childbirth, after adjustment for all covariates, including provincial fixed effects.

Length of Stay				
		IRR [95%CI]	**p-value**	**Predicted LOS (days) [95%CI]**
Mode of delivery	Vaginal	1.00		2.15 [2.11, 2.19]
	Caesarian	1.78 [1.69, 1.87]	>0.01	3.82 [3.64, 4.00]
Nulliparity	Subsequent birth	1.00		2.34 [2.27, 2.42]
	First birth	1.31 [1.25, 1.38]	>0.01	3.08 [2.97, 3.18]
Maternal Readmissions				
		OR [95%CI]	**p-value**	**Predicted probability % [95%CI]**
Mode of delivery	Vaginal	1.00		1.13 [0.83, 1.44]
	Caesarian	1.53 [0.97, 2.41]	0.07	1.72 [1.14, 2.29]
Nulliparity	Subsequent birth	1.00		1.16 [0.84, 1.49]
	First birth	1.39 [0.85, 2.25]	0.19	1.60 [1.10,2.15]
Pre-delivery Admissions				
		OR [95%CI]	**p-value**	**Predicted probability % [95%CI]**
Nulliparity	Subsequent birth	1.00		4.00 [3.42, 4.57]
	First birth	1.22 [0.93, 1.60]	0.15	4.82 [3.89, 5.75]

Table 8. Measures of association between provinces/territories and predicted LOS in days, adjusted for individual-level factors.

Province	Length of Stay (days)		
	Adjusted IRR [95% CI]	p-value	Predicted LOS [95% CI]
Ontario (reference)	1.00		2.39 [2.29, 2.48]
P.E.I.	1.50 [1.29, 1.74]	>0.01	3.58 [3.07, 4.09]
Nova Scotia	1.33 [1.21, 1.47]	>0.01	3.18 [2.91, 3.44]
New Brunswick	1.29 [1.18, 1.41]	>0.01	3.08 [2.86, 3.31]
Newfoundland/ Labrador	1.39 [1.23, 1.59]	>0.01	3.33 [2.93, 3.72]
Manitoba	1.14 [1.08, 1.21]	>0.01	2.72 [2.60, 2.84]
Saskatchewan	1.20 [1.11, 1.29]	>0.01	2.86 [2.68, 3.03]
Alberta	0.98 [0.91, 1.05]	0.52	2.33 [2.18, 2.49]
British Columbia	1.10 [1.02, 1.19]	>0.01	2.63 [2.46, 2.80]
Territories (NT/NU/YT)	1.11 [1.03, 1.20]	>0.01	2.65 [2.46, 2.83]

Table 9. Secular trends are present in predicted LOS and admission probabilities after adjusting for individual-level factors, as well as provincial fixed effects.

	Delivery LOS	Maternal readmission	Pre-delivery Admission
DAD year	Predicted days [95%CI] (7,163 deliveries)	predicted % probability [95%CI] (102 readmissions)	predicted % probability [95%CI] (329 admissions)
2005	2.79 [2.66, 2.92]	1.3 [0.7, 1.8]	4.6 [3.6, 5.7]
2006	2.65 [2.57, 2.74]	1.7 [1.1, 2.4]	5.3 [4.2, 6.4]
2007	2.66 [2.49, 2.82]	1.1 [0.6, 1.6]	3.6 [2.7, 4.6]
2008	2.55 [2.42, 2.69]	1.2 [0.6, 1.8]	4.3 [3.2, 5.4]
2009	2.38 [2.27, 2.48]	1.2 [0.6, 1.8]	3.2 [2.2, 4.2]

Of all individual-level factors I examined in relation to hospital utilization, the most striking was that of Aboriginal status, particularly in relation to rural residence (Table 10, Table 11). In terms of LOS, variation in hospital utilization for delivery solely by Aboriginal status was negligible with an average 2% shorter stay than non-Aboriginal women (IRR = 0.98 [0.92, 1.03]) before adjusting for other covariates. After adjusting for other factors including provincial fixed effects, Aboriginal women were observed to have a 3% longer stay than non-Aboriginal women (IRR = 1.03 [0.97, 1.010]). Odds ratios of 1.51 [0.85, 2.68] and 1.64 [1.19, 2.25], were seen for maternal readmissions and pre-delivery admissions in Aboriginal women compared to non-Aboriginal women in the unadjusted models, however these were abolished after controlling for other factors.

Incorporation of an interaction term in the logistic regression model for maternal readmission revealed evidence of effect measure modification between Aboriginal status and rural area of residence (Table 11). An imprecise but substantial increase in the probability of maternal readmission for Aboriginal women living in rural areas was observed at 3.66% [0.50, 6.83] after adjusting for other factors and province, relative to Aboriginal women living in urban areas (1.37% [0.24, 2.50]) and non-Aboriginal women in rural (1.11% [0.57, 1.65]) or urban areas (1.28% [0.95, 1.60]). No evidence of similar interaction was seen in LOS or pre-delivery maternal admission (Table 10).

Table 10 Point estimates for LOS, risk of maternal readmission, and risk of pre-delivery admission by Aboriginal status, area of residence, and the interaction term between Aboriginal status and rural area of residence. Unadjusted and adjusted estimates are given.

LENGTH OF STAY												
	Unadjusted				**Adjusted**				**Adjusted with provincial FE**			
	IRR	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*IRR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*IRR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*
Urban	1.00				1.00				1.00			
Rural	1.10	<0.01	1.03	1.17	1.15	<0.01	1.08	1.23	1.11	0.01	1.03	1.19
Non-Aboriginal status	1.00				1.00				1.00			
Aboriginal status	0.98	0.42	0.92	1.03	1.05	0.14	0.98	1.12	1.03	0.32	0.97	1.10
Interaction term	N/A	N/A	N/A	N/A	0.96	0.52	0.85	1.09	0.97	0.61	0.85	1.10
RISK OF MATERNAL READMISSION												
	Unadjusted				**Adjusted**				**Adjusted with provincial FE**			
	OR	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*OR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*OR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*
Urban	1.00				1.00				1.00			
Rural	1.10	0.69	0.69	1.76	0.94	0.83	0.53	1.66	0.87	0.62	0.49	1.54
Non-Aboriginal status	1.00				1.00				1.00			
Aboriginal status	1.51	0.16	0.85	2.68	1.15	0.75	0.49	2.68	1.07	0.88	0.43	2.66
Interaction term	N/A	N/A	N/A	N/A	2.82	0.09	0.84	9.54	3.21	0.07	0.90	11.40
RISK OF PRE-DELIVERY ADMISSION												
	Unadjusted				**Adjusted**				**Adjusted with provincial FE**			
	OR	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*OR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*OR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*
Urban	1.00				1.00				1.00			
Rural	1.40	0.01	1.09	1.81	1.32	0.06	0.99	1.75	1.22	0.17	0.92	1.60
Non-Aboriginal status	1.00				1.00				1.00			
Aboriginal status	1.64	<0.01	1.19	2.25	1.29	0.22	0.86	1.95	1.07	0.76	0.69	1.67
Interaction term	N/A	N/A	N/A	N/A	0.86	0.67	0.43	1.71	0.91	0.79	0.45	1.82

Table 11 Predicted probabilities of readmission, stratified by Aboriginal status and rural area of residence when an interaction term is introduced between Aboriginal status and rural area of residence.

	Adjusted % predicted probability, without provincial fixed effects (95% CI)		Adjusted % predicted probability, with provincial fixed effects (95% CI)	
	Non-Aboriginal	Aboriginal	Non-Aboriginal	Aboriginal
Urban	1.25 [0.93, 1.56]	1.43 [0.32, 2.54]	1.28 [0.95, 1.60]	1.37 [0.24, 2.50]
Rural	1.18 [0.60, 1.75]	3.68 [0.71, 6.65]	1.11 [0.57, 1.65]	3.66 [0.50, 6.83]

CHAPTER 5: DISCUSSION

In this study, I used a population-based linkage of hospital utilization data with socio-demographic factors from CCHS survey respondents who had agreed to link and share their information. The objectives were to first to describe the maternal characteristics of the sample to assess their representativeness of the Canadian population. Next, the association between individual-level household income as a measure of SES and hospital utilization related to childbirth was evaluated using negative binomial and logistic regression models. A sub-analysis of women over the age of 25 was also carried out to determine whether maternal education might confound the relationship between income and hospital burden for childbirth. Then, individual-level socio-demographic and clinical risk factors that have been shown to impact hospital utilization for childbirth were included and examined as covariates in the adjusted models.

Linked sample exhibited characteristics similar to the Canadian trends in childbirth

Maternal demographic and socioeconomic characteristics of the sample revealed remarkable likeness to reported Canadian trends, despite being limited to those who were selected and responded to the CCHS and agreed to link and share their responses. The predicted LOS for C-sections and vaginal deliveries were consistent with the average LOSs reported by CIHI and PHAC as being 3.4 days and 2.0-2.2 days, respectively (16, 17). Length of stay was modestly patterned by household income longest stays for lowest income women (2.79 days, 95% CI 2.61-2.92), followed by middle income women (2.63 days, 95% CI 2.50-2.76) and, in turn, high income women (2.56 days, 95% CI 2.49-2.63). Biological and administrative factors were found to be the strongest drivers of hospital utilization for childbirth. Similar to predictors of LOS, delivery by Caesarian section was the strongest single predictor of readmission, a relationship

well-known in the national data (16) due to increased risk of pelvic injury or wounds, obstetric complications, venous disorders and thromboembolism, or puerperal infections (44). Provincial and territorial differences found in this study were also consistent with differences in LOS and most other delivery aspects reported by PHAC and CIHI (16, 23). Moreover, decreases in LOS observed in this study period of five years have been similarly documented in national perinatal health trends from 1995 and 2005 (16).

The data linkage to all discharges for each individual during the period under study allowed for the identification of maternal admissions surrounding delivery, as well as the most prevalent diagnoses associated with those admissions. Despite differences in the window of time analyzed after birth, the percentage of deliveries associated with a 30-day maternal readmission found in this study (1.33%) seems comparable to the 90-day maternal readmission rates of between 2.7-3.7 readmissions per 100 deliveries between 1995 and 2005 (16, 43). The most common diagnoses are consistent with previous population-wide data on prenatal and post-partum readmissions (41, 43, 44).

Examining the socio-demographic data available for the 5.77% of the sample who did not report income revealed these individuals were more likely to be adolescent, less educated, and un-partnered. The observed non-response rate is somewhat lower than previously reported non-response rates for income-related items in population-based surveys, ranging from 17-30% for the CCHS (174). Omission of these individuals might introduce non-response bias, leaving a high probability that women of lower socioeconomic status were excluded from the analysis. This makes the Canadian population of women giving birth appear higher in socioeconomic status than they are in reality, and could bias the association between SES and utilization toward the null hypothesis. A previous Canadian study found evidence of selection bias towards the null

in the association between SES and birth outcomes for hospital-based data by comparing estimates to those found for population-based data (85). Sensitivity analyses could be performed to establish the extent of potential bias caused in omitting these individuals from the analysis.

Further examination of maternal socio-demographic characteristics also revealed a high teenage pregnancy rate in Aboriginal girls, as compared to non-Aboriginal girls. The 14.37% teenage pregnancy rate found in this sample overall exceeds the WHO's global estimate of teenage pregnancy at 10%. In their analysis of 2006 Canadian census data, Garner et al. (118) also found much higher rates of pregnancy in First Nations teens than non-First Nations teens, and were even higher in those living on-reserve. The rate of teen pregnancy in Aboriginal women obtained from this study is likely an underestimate, as the CCHS does not cover women living on reserves. Teenage pregnancy is an important issue for Canadian Aboriginal girls and infants, given its association with adverse health outcome such as PTB, LBW (131, 175-178), birth defects(179), and higher infant mortality rates (180). Lack or underutilization of PNC (181, 182) has also been observed for this group. Another study found that Inuit children who were born to younger mothers tended to have worse maternally-reported physical health and emotional development, as well as higher likelihood of ear infections and dental problems (183).

Income was modestly associated with length of stay in hospital for birth events

After controlling for delivery-related characteristics and administrative differences between provinces, modest income gradients in hospital utilization were detected. The analysis of hospital utilization by individual-level income groupings represents an improvement upon previous work using area-level income (19-21, 86, 88, 98, 160), as well as an expansion of delivery utilization aspects to include admissions immediately surrounding delivery. Several studies showed similarly modest differences among women by income-related measures, with a tendency for the

lowest income group to exhibit the highest utilization (21, 155, 157, 159, 160). The findings of this study are generally consistent with the literature showing modest associations between household income levels and hospital burden. However, previous studies have used neonatal readmission as the main utilization outcome, so a direct comparison with rates of maternal readmission makes little sense.

Past studies have relied on area-based income measures as a proxy for individual income, which are prone to attenuated income trends due to non-differential misclassification bias. Daoud et al. (92) demonstrated this phenomenon by using individual and neighborhood socioeconomic measures in parallel, and showed that stronger socioeconomic gradients in child and maternal health outcomes were seen when using individual-level measures. We might have anticipated more pronounced trends in maternal hospital utilization for this study using individual-level income. Studies that have used area-based income have shown stronger trends in hospital utilization for childbirth (19, 20, 160) than that seen here, even after adjusting for multiple variables. Two previous studies (19, 156) found that income-related characteristics were a main predictor of neonatal readmission. However, these studies focused on neonatal utilization outcomes as opposed to maternal utilization outcomes, which could mean that neonatal health is more sensitive to SES than maternal health is to SES – at least within the time surrounding delivery. Moreover, these studies were conducted in single provinces, while this sample has a diverse context of multiple provincial socioeconomic and healthcare settings. One study noted that both income and geography were the two major variables associated with neonatal readmission (19).

Household income is sensitive to regional differences in geography and cost of living. Statistics Canada has calculated income deciles that take into account the low-income cutoff, province,

household size, and community size. However, these adjusted values were not available for women in the territories (n = 330), nor were they included as imputed missing values. I opted to use the household income variable that was available for provinces and territories to ensure the inclusion of these additional 330 cases.

Income is highly variable over time, and has different ramifications over the life course. It is not a very useful marker of SES for younger women, who would not have had the time to complete their education. The inclusion of maternal education in the sub-analysis excluding deliveries from women under the age of 25 further diminished the slight inverse relationship between low income and higher hospital utilization. It also attenuated the difference in hospital burden seen between the highest and lowest income groups. The changes in estimates for income patterning indicate maternal education is a potential confounder in the association between income and hospital utilization for delivery in adult women.

My objective was to make a comprehensive assessment of SES and delivery in Canada that would apply to a diverse Canadian sample. Household income is indicative of women's access to maternal resources in a critical time for maternal and child health. The results of this study indicate a modest income-related gradient in length of stay, estimated to be an 8% difference in predicted length of stay between high and low income groups after adjusting for covariates. While the results are statistically inconclusive, the analysis suggests low-income women have marginally longer stays in hospital following birth events than middle and high-income women in Canada that persist after adjustment for strong drivers of length of stay (parity and birth mode). The absence of major differences in hospital burden among women of different socioeconomic positions lends evidence that the principles of equity and universality are being attained, which is foundational to the Canadian health care system. In the interest of maintaining

the effectiveness of child and maternal health in this country, future work might build upon the success of health care services for childbirth by investigating potential longitudinal health outcomes and the hospital burden of poverty, with a focus on child health and later maternal health. The subtle differences that were noted still raise the question as to whether there may be additional reductions in length of stay that could be achieved through resource redistribution to the prenatal period.

Logistic regression on the risk of postpartum maternal readmission reveals interaction between Aboriginal status and rural area of residence.

In the course of the analysis for income and hospitalization for childbirth, other individual-level factors known to be associated with hospital utilization were adjusted for and examined in the models of LOS and surrounding maternal admissions. While the point estimates for the interaction were imprecise, this study suggests that Aboriginal women living in rural areas could be at increased risk of maternal readmission as compared to Aboriginal women living in urban areas, and non-Aboriginal women regardless of residence. Previous studies have also detected differences in childbirth outcomes for Aboriginal women related to area of residence (113, 184), however the relationship appears to be dependent on the social and geographic context. One study that focused on First Nations communities in Quebec found that residing in more remote areas was associated with higher risk of post-neonatal and fetal death (185), while a different study found that decreases in infant mortality were less pronounced and consistent for urban First Nations women as compared to rural First Nations women and non-First Nations women (184). Aboriginal women commonly report experiences of isolation associated with delivering away from family and community (186), which may affect uptake of preventive or follow-up care. The increased risk of readmission for rural Aboriginal women might suggest poorer access to

preventive perinatal care (184) in these regions resulting in increased complications, or perhaps a cautious return to hospital soon after delivery before a long commute home. This study represents one of the few multi-province/territory health datasets that includes an Aboriginal identifier, and will enable future studies in Indigenous health in Canada. I have provided evidence that the relationship between Aboriginal status and utilization for delivery is sensitive to area of residence, which has also been seen in the literature (115, 185). However, the Indigenous peoples of Canada are diverse, as are the social, geographic, and historical contexts in which they live. More detailed studies are needed in order to comprehensively characterize the relationship between Aboriginal status, geography, and hospital utilization for childbirth.

CHAPTER 6: CONCLUSION

Contributions

Substantive contributions

Prior studies at the level of regions and institutions have produced mixed results on the relationship between income and delivery hospitalization in Canada. In this study, I established that length of stay and readmission were modestly patterned by household income in models that accounted for major biological (birth mode) and system-related (e.g., province) drivers of length of stay for a large sample of Canadian women. The pregnancy rate for Aboriginal teens was found to be very high in this study at 14%, especially vis-à-vis the rate for non-Aboriginal teens at 3%. Hospital burden was elevated for Aboriginal women, particularly for those living in rural areas.

Past studies that consider the 'determinants' of utilization associated with childbirth typically consider delivery LOS and neonatal readmission in relation to SES. Using a wider window of hospital utilization related to delivery, we now know that the maternal admissions surrounding delivery are patterned by some maternal characteristics, and were not observed for the analysis of LOS. One interpretation of the differences seen between the three utilization measures could be that surrounding admissions are more indicative of SES differences in hospital burden, whereas the LOS at delivery has been standardized to such an extent that it serves as a measure of hospital efficiency for the medical procedure. Moreover, examining multiple measures of hospital burden might also reveal greater insight and detail into the nature of utilization. Socioeconomic differences might be seen in one measure of hospital burden, and not necessarily

in another. The events adjacent to delivery could be meaningful to child and maternal health disparities, and deserve future consideration.

Methodological contributions

The existing literature on income, childbirth outcomes and hospital utilization suffers from three limitations. First, there is a dearth of research able to address individual-level SES and demographic factors in connection to health outcomes within a multi-province/territory sample. Previous SES studies were limited to single regions or specific hospitals, and were not based on a large national sample. Second, studies of childbirth at the national level lack the SES and demographic variables in their use of Canadian administrative data. Third, most cross-sectional studies are restricted to a particular time of interest, and have few plans to build on existing cross-sectional datasets to incorporate future health outcomes.

This research represents the first population-based examination of individual socio-demographic factors linked with hospital burden for childbirth taking place in multiple Canadian provinces and territories. Surveys like the CCHS have a wide array of detailed information on health topics and behavioral conditions, and are often carried out using rigorous sampling frames to ensure adequate representation of the population (150). Moreover, other surveys such as the Ontario Child Health Study (187) permit the assessment of the association between early-life exposures and health care utilization later in life, particularly during critical life stages that could be more sensitive to socioeconomic conditions, such as early childhood and adolescence (143). Linkage between survey data and administrative utilization measures aids in determining the potential contribution of socioeconomic and demographic conditions to health outcomes and hospital burden. Furthermore, the availability of data by province/territory and date of discharge might make more ecological and multi-level studies possible, as well as shed light on the effect of

implementing regional health interventions and policies at different periods in time. Manitoba and Nova Scotia are currently the two provinces where person-oriented databases have been more commonly used for multi-level modeling in population research (143). Lastly, this records linkage allows us to identify the groups at risk for healthcare research in general, and in the case of childbirth, has allowed us to assess equity of delivery and health status across different socioeconomic gradients.

Previous studies on readmissions related to childbirth in Canada have examined neonatal readmission, and therefore relied on good linkage between mother and infant hospital discharge abstracts (19, 159) or on interview methods with smaller samples (156, 158). Those that focused on maternal readmissions have used linkage primarily by HIN (41, 43) to identify other discharges within a certain time period. The linkage used in this thesis was composed of survey respondents that have already been linked deterministically (including HIN) and probabilistically to all existing discharge records in the administrative database between 2005 and 2009. The novelty of the linked dataset allowed for robust identification of admissions related to an index hospitalization event (eg. delivery for childbirth). Therefore, the task of identifying admissions adjacent to delivery involved calculating elapsed times between admissions and discharges, and isolating those occurring between 24 hours and 30 days from a birth event. The high quality linkage of several events to a single individual is the key feature that allowed for the identification of maternal admissions surrounding delivery. The person-oriented nature of this linkage will enable us to answer research questions that could have previously only been asked of cohort studies.

Policy implications

Canada's universal health care system tends to be viewed favourably in terms of assuring access based on need, and not on ability to pay. This study suggests maternal hospitalization for childbirth is equitable and consistent, regardless of women's income status, and other socio-demographic characteristics. While low income individuals exhibited small increases in resource utilization, this research suggests an overall "good news" story for Canadian health care, especially considering income is a determinant of birth outcome, as well as a key factor for women's health (188). The evidence that hospital burden for childbirth in Canada is primarily driven by biological and regional differences, rather than by socioeconomic position, bodes well for the health care system's ability to equitably provide maternal care related to childbirth, and is worth preserving as a matter of good health policy. That said, the length of stay differences that persisted in fully adjusted models do suggest that there may be potential to trade resource allocation from hospitalization into the prenatal period to reduce income-related hospital burden even further.

The importance of collecting information on Aboriginal status for health research is clear, given the overwhelming disparities seen in Canada between Aboriginal and non-Aboriginal Canadians. Using a multi-province and territory Aboriginal identifier, this study was able to detect high rates of teenage pregnancy in Aboriginal girls, as well as higher risk of maternal readmission for Aboriginal women living in rural areas. These groups may be potential populations for targeted interventions, specifically in the postpartum period for rural women, or indicate the need for evaluation of the services already in existence for these populations. Linkage to infant abstracts could also give us further insight into the effects of maternal SES on longer-term childhood health and development.

This study demonstrates the utility of national administrative data in linkage studies to answer questions about Canadian population health. The differences in SES patterning between LOS, maternal readmission, and pre-delivery admission underline the value of examining multiple measures of utilization, and this was made possible using linked data. However, administrative data is still collected without anticipating its potential for research use, and often requires considerable quality control and cleaning prior to analysis. In view of these benefits to health research, health policy might consider embedding mechanisms for planned linkage (189) in the future collection and maintenance of large-scale administrative databases.

Strengths and Limitations

While the data and findings are both promising and informative, there are three points of caution. The first relates to constraints of the survey sample. The data were drawn from a population-based survey, however it is important to note that the sample is not nationally representative, and excludes Quebec. Although Aboriginal status and rural status emerged as drivers of maternal readmission, the CCHS did not include individuals living on reserves. Past studies have indicated higher rates of teenage pregnancy in on-reserve Aboriginal women as compared with off-reserve Aboriginal women (118). Compounding the issue is poverty, poorer housing conditions, and poorer access to services according to the First Nations Regional Health Survey (190). Higher rates of PTB and SGA have been found in off-reserve Aboriginal infants, whereas higher rates of neonatal death were found in on-reserve infants (191). The absence of sampling in on-reserve individuals that differ in SES and health status from the general Canadian population may have led to an underestimate of association between low-income, poorer health outcomes, and higher health care utilization.

A last aspect of the survey sample that warrants caution is that the non-responders for income were different from responders. Non-responders tended to be women of lower SES. Excluding these women from the analysis would result in an artificially higher SES sample, and introduce non-response bias towards the null hypothesis - in that this sample would also potentially have better health status and lower health care needs.

A second point of caution relates to the absence of mother-infant health care record linkages. The linkage of records between mother and infant was not possible for this dataset due to different administrative practices by province, in addition to the fact that there are no newborns in the CCHS. This means we were unable to detect and link neonatal readmissions to maternal factors at this time.

As a third and final point, this study is sensitive to all limitations associated with the use of administrative data for health research (142), particularly with regard to incomplete information (as was the case for parity) as well as the level of detail in health outcomes and utilization type. For instance, emergency department visits were not consistently recorded in the DAD, and their absence likely results in underestimated health care burden.

The major strength of this study is the use and validation of a records linkage of individual-level factors to hospital utilization measures from a Canada-wide administrative database. SES and demographic factors were drawn from a population-based, national survey, and even though the linkage depends on the quality of the survey sampling and agreement from respondents to link and share their records, there is a high degree of similarity in the frequencies of maternal and delivery utilization characteristics to other national data analyses. Another strength of this study is that the joining of an individual to all of their hospital discharge records from 2005-09 enabled the detection of multiple pregnancies from a single woman, as well as consideration of

differences in hospital admissions surrounding birth and delivery. Future studies using this dataset could involve hospital utilization over the life-course, with potential to add forthcoming discharge abstracts to this linked dataset. Lastly, while a greater number of reports have analyzed SES in relation to adverse birth outcomes, fewer have attempted to look specifically at hospital utilization as an indicator of population health and equity, and as an outcome of economic and health policy interest in and of itself. The purpose of this study was to determine whether there were hospital utilization differences among women of different income levels in Canada, where hospital utilization in a universal health care setting is more likely to be related to health status, and less likely to be affected by individual financial barriers.

This study provides evidence that birth-related hospital utilization in Canada is primarily driven by biological and administrative factors, and subtly patterned by socio-demographic maternal characteristics. It suggests that equity goals of the Canadian health care system, embedded in the Canada Health Act, are mainly being achieved for birth-related hospitalizations. Remaining income-related differences in hospitalization could, however, still be considered for resource redistribution. In other words, the additional hospital resources that have been shown here to be directed to low income women for childbirth might be better directed to the prenatal period.

Our apparent success in maternal health, while laudable, now motivates advancement in other areas of women's health that may not be so brief and clearly defined as that of "childbirth." The scope of studies in the perinatal period is necessarily narrow, but without the broader context of women's health and poverty, we will miss opportunities to make health and social policies that can maintain the successes observed during the perinatal period, as well as improve health and conditions throughout the life course. In the end, poverty-alleviating measures might make the most sense to remedy income inequality as a determinant of overall health [20]. Large-scale

federal programs such as the Canada Child Tax Benefit and the Universal Child Care Benefit are meant to respond to the added financial burden of childcare. These programs administer a tax-free monthly payment to families raising children, but are insufficient to fully support these women, or advance women's economic security in general. Furthermore, such economic interventions have not considered potential gains to be made in the area of health care use and health outcomes. Linked data initiatives like this are an avenue for more complete research in women's health and childhood health related to socio-demographic factors. The availability of these data will be key for comprehensive evaluation of population health status, and essential to informing health policy that will flow from such evaluation.

APPENDICES

Table 12 ICD-10-CA codes used to identify deliveries, and CMG codes used to identify C-section births.

Delivery and Caesarian Codes	
ICD-10-CA Delivery codes	Any one diagnosis code of O10 to O16, O21 to O29, O30 to O46, O48, O60 to O75, O85 to O92, O95 or O98 to O99, with a sixth digit of 1 or 2 or Z37
Case Mix Group (CMG) codes	CMG codes 536 and 537 were used to classify births as Caesarian deliveries CMG codes 538-545 were used to classify births as Vaginal deliveries

Table 13 Proportion of C-section births by province.

Province of delivery	#Vaginal births (% in province)	#Caesarian births (% in province)	Total in province
Ontario	2173 (72.00)	845 (28.00)	3018
Prince Edward Island	102 (72.34)	39 (27.66)	141
Nova Scotia	236 (71.08)	96 (28.92)	332
New Brunswick	247 (69.58)	108 (30.42)	355
Newfoundland	187 (65.61)	98 (34.39)	285
Manitoba	522 (78.14)	146 (21.86)	668
Saskatchewan	562 (77.62)	162 (22.38)	724
Alberta	669 (71.09)	272 (28.91)	941
British Columbia	619 (70.34)	261 (29.66)	880
Northwest Territories	120 (86.96)	18 (13.04)	138
Nunavut	67 (93.06)	5 (6.94)	72
Yukon Territory	46 (69.70)	20 (30.30)	66

Table 14. Full negative binomial regression models for delivery LOS.

LENGTH OF STAY (7,163 deliveries, 5,568 individuals)													
		Unadjusted				Adjusted				Adjusted with provincial FE			
		IRR	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*IRR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*IRR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*
Household Income	High	1.00				1.00				1.00			
	Medium	1.04	0.28	0.97	1.10	1.05	0.09	0.99	1.11	1.03	0.31	0.97	1.09
	Low	1.04	0.21	0.98	1.11	1.10	<0.01	1.03	1.17	1.08	0.02	1.01	1.15
Maternal age (rescaled)		1.03	0.02	1.00	1.05	1.04	<0.01	1.02	*1.07*		1.04	0.00	1.02
Nulliparity	Subsequent birth	1.00				1.00				1.00			
	First birth	1.30	<0.01	1.24	1.36	1.28	<0.01	1.22	1.35	1.31	<0.01	1.25	1.38
Aboriginal status	Non-Aboriginal	1.00				1.00				1.00			
	Aboriginal	0.98	0.42	0.92	1.03	1.03	0.29	0.97	1.10	1.02	0.44	0.96	1.09
Residence	Urban	1.00				1.00				1.00			
	Rural	1.10	<0.01	1.03	1.17	1.15	<0.01	1.08	1.22	1.10	0.01	1.03	1.18
Marital status	Partnered	1.00				1.00				1.00			
	Un-partnered	1.09	0.01	1.02	1.17	1.05	0.21	0.98	1.12	1.04	0.31	0.97	1.12
Recent immigrant	No	1.00				1.00				1.00			
	Yes	0.92	0.07	0.85	1.01	0.92	0.03	0.85	0.99	0.97	0.38	0.90	1.04
Province	ON	1.00								1.00			
	PE	1.47	<0.01	1.25	1.72					1.50	<0.01	1.29	1.74
	NS	1.34	<0.01	1.21	1.48					1.33	<0.01	1.21	1.47
	NB	1.32	<0.01	1.20	1.44					1.29	<0.01	1.18	1.41
	NL	1.46	<0.01	1.26	1.68					1.39	<0.01	1.23	1.59
	MB	1.08	0.02	1.01	1.16					1.14	<0.01	1.08	1.21
	SK	1.15	<0.01	1.06	1.24					1.20	<0.01	1.11	1.29
	AB	0.98	0.58	0.90	1.06					0.98	0.54	0.91	1.05
	BC	1.10	0.03	1.01	1.20					1.10	0.01	1.02	1.19
	YT/NT/NU	1.04	0.43	0.95	1.13					1.11	0.01	1.03	1.20
Year of delivery	2005	1.00				1.00				1.00			
	2006	0.98	0.41	0.92	1.03	0.95	0.06	0.90	1.00	0.95	0.06	0.90	1.00
	2007	0.98	0.55	0.90	1.06	0.95	0.16	0.88	1.02	0.95	0.19	0.88	1.02
	2008	0.94	0.13	0.87	1.02	0.91	0.01	0.85	0.98	0.92	0.02	0.85	0.98
	2009	0.88	<0.01	0.83	0.94	0.85	<0.01	0.79	0.91	0.85	<0.01	0.80	0.91
Mode of delivery	Vaginal	1.00				1.00				1.00			
	Caesarian	1.82	<0.01	1.73	1.92	1.79	<0.01	1.70	1.87	1.78	<0.01	1.69	1.87

Table 15. Full logistic regression results for the risk of maternal readmission within 30 days of discharge for delivery.

RISK OF MATERNAL READMISSION (WITHIN 30 DAYS AFTER DISCHARGE FOR DELIVERY) (7,163 deliveries, 5,568 individuals)													
		Unadjusted				**Adjusted**				**Adjusted with provincial FE**			
		OR	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*OR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*OR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*
Household Income	High	1.00				1.00				1.00			
	Medium	0.74	0.33	0.40	1.36	0.78	0.44	0.42	1.46	0.73	0.33	0.39	1.37
	Low	1.26	0.35	0.78	2.04	1.36	0.33	0.73	2.53	1.28	0.43	0.69	2.39
Maternal age (rescaled)		1.18	0.07	0.99	1.41	1.25	0.04	1.01	1.54	1.26	0.03	1.02	1.55
LOS for delivery (days)		1.05	<0.01	1.03	1.08	1.04	<0.01	1.02	1.07	1.05	<0.01	1.02	1.07
Nulliparity	Subsequent birth	1.00				1.00				1.00			
	First birth	1.21	0.37	0.80	1.84	1.30	0.29	0.80	2.12	1.39	0.19	0.85	2.25
Aboriginal status	Non-Aboriginal	1.00				1.00				1.00			
	Aboriginal	1.51	0.16	0.85	2.68	1.15	0.75	0.49	2.68	1.07	0.88	0.43	2.66
Residence	Urban	1.00				1.00				1.00			
	Rural	1.10	0.69	0.69	1.76	0.94	0.83	0.53	1.66	0.87	0.62	0.49	1.54
Marital status	Partnered	1.00				1.00				1.00			
	Un-partnered	1.15	0.56	0.72	1.82	1.04	0.90	0.59	1.82	1.00	0.99	0.57	1.77
Recent immigrant	No	1.00				1.00				1.00			
	Yes	1.10	0.81	0.51	2.38	1.06	0.88	0.47	2.41	1.22	0.64	0.54	2.76
Province	ON	1.00								1.00			
	PE	0.90	0.92	0.12	6.73					1.00	1.00	0.14	7.25
	NS	3.42	<0.01	1.58	7.36					3.76	<0.01	1.72	8.20
	NB	1.72	0.27	0.66	4.50					1.94	0.19	0.73	5.16
	NL	1.73	0.31	0.60	4.97					1.56	0.43	0.52	4.69
	MB	2.21	0.03	1.10	4.41					2.25	0.04	1.05	4.82
	SK	1.91	0.07	0.94	3.89					1.86	0.12	0.85	4.06
	AB	1.46	0.30	0.72	2.97					1.50	0.28	0.72	3.12
	BC	1.80	0.10	0.89	3.66					1.76	0.12	0.86	3.58
	YT/NT/NU	1.37	0.61	0.41	4.57					1.06	0.93	0.28	4.01
Year of delivery	2005	1.00				1.00				1.00			
	2006	1.36	0.31	0.75	2.47	1.34	0.34	0.74	2.44	1.36	0.32	0.74	2.48
	2007	0.91	0.77	0.47	1.75	0.86	0.66	0.44	1.68	0.86	0.65	0.44	1.68
	2008	0.95	0.88	0.49	1.86	0.92	0.81	0.47	1.82	0.94	0.85	0.48	1.85
	2009	0.99	0.97	0.50	1.93	0.95	0.89	0.47	1.90	0.97	0.93	0.48	1.95
Mode of delivery	Vaginal	1.00				1.00				1.00			
	Caesarian	1.82	<0.01	1.21	2.75	1.55	0.06	0.98	2.43	1.53	0.07	0.97	2.41

Table 16 Full logistic regression results for the risk of maternal admission within 30 days prior to admission for delivery.

RISK OF MATERNAL READMISSION (WITHIN 30 DAYS AFTER DISCHARGE FOR DELIVERY) (7,163 deliveries, 5,568 individuals)													
		Unadjusted				**Adjusted**				**Adjusted with provincial FE**			
		OR	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*OR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*	*OR*	*P-value*	*Lower 95% CI*	*Upper 95%CI*
Household Income	High	1.00				1.00				1.00			
	Medium	0.74	0.33	0.40	1.36	0.78	0.44	0.42	1.46	0.73	0.33	0.39	1.37
	Low	1.26	0.35	0.78	2.04	1.36	0.33	0.73	2.53	1.28	0.43	0.69	2.39
Maternal age (rescaled)		1.18	0.07	0.99	1.41	1.25	0.04	1.01	1.54	1.26	0.03	1.02	1.55
LOS for delivery (days)		1.05	<0.01	1.03	1.08	1.04	<0.01	1.02	1.07	1.05	<0.01	1.02	1.07
Nulliparity	Subsequent birth	1.00				1.00				1.00			
	First birth	1.21	0.37	0.80	1.84	1.30	0.29	0.80	2.12	1.39	0.19	0.85	2.25
Aboriginal status	Non-Aboriginal	1.00				1.00				1.00			
	Aboriginal	1.51	0.16	0.85	2.68	1.15	0.75	0.49	2.68	1.07	0.88	0.43	2.66
Residence	Urban	1.00				1.00				1.00			
	Rural	1.10	0.69	0.69	1.76	0.94	0.83	0.53	1.66	0.87	0.62	0.49	1.54
Marital status	Partnered	1.00				1.00				1.00			
	Un-partnered	1.15	0.56	0.72	1.82	1.04	0.90	0.59	1.82	1.00	0.99	0.57	1.77
Recent immigrant	No	1.00				1.00				1.00			
	Yes	1.10	0.81	0.51	2.38	1.06	0.88	0.47	2.41	1.22	0.64	0.54	2.76
Province	ON	1.00								1.00			
	PE	0.90	0.92	0.12	6.73					1.00	1.00	0.14	7.25
	NS	3.42	<0.01	1.58	7.36					3.76	<0.01	1.72	8.20
	NB	1.72	0.27	0.66	4.50					1.94	0.19	0.73	5.16
	NL	1.73	0.31	0.60	4.97					1.56	0.43	0.52	4.69
	MB	2.21	0.03	1.10	4.41					2.25	0.04	1.05	4.82
	SK	1.91	0.07	0.94	3.89					1.86	0.12	0.85	4.06
	AB	1.46	0.30	0.72	2.97					1.50	0.28	0.72	3.12
	BC	1.80	0.10	0.89	3.66					1.76	0.12	0.86	3.58
	YT/NT/NU	1.37	0.61	0.41	4.57					1.06	0.93	0.28	4.01
Year of delivery	2005	1.00				1.00				1.00			
	2006	1.36	0.31	0.75	2.47	1.34	0.34	0.74	2.44	1.36	0.32	0.74	2.48
	2007	0.91	0.77	0.47	1.75	0.86	0.66	0.44	1.68	0.86	0.65	0.44	1.68
	2008	0.95	0.88	0.49	1.86	0.92	0.81	0.47	1.82	0.94	0.85	0.48	1.85
	2009	0.99	0.97	0.50	1.93	0.95	0.89	0.47	1.90	0.97	0.93	0.48	1.95
Mode of delivery	Vaginal	1.00				1.00				1.00			
	Caesarian	1.82	<0.01	1.21	2.75	1.55	0.06	0.98	2.43	1.53	0.07	0.97	2.41

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